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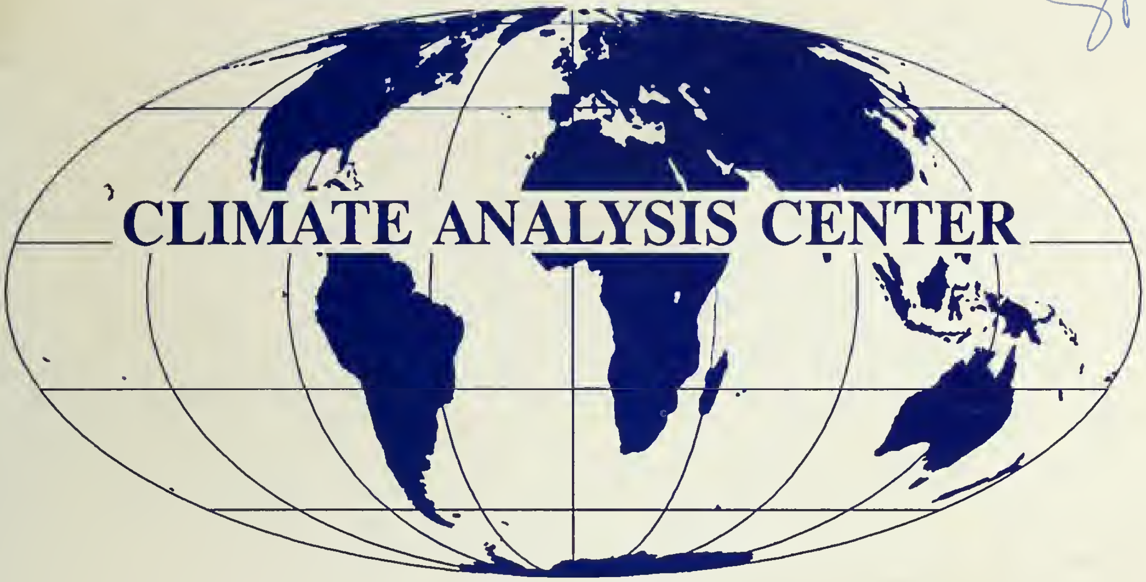

CLIMATE ANALYSIS CENTER

FY 1992

ANNUAL REPORT

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
National Meteorological Center

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CLIMATE ANALYSIS CENTER
FY 1992
ANNUAL REPORT

TECHNICAL EDITOR: LUKE MANNELLO

January 1993

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
National Meteorological Center

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FY 1992 ANNUAL REPORT

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EXECUTIVE SUMMARY

David R. Rodenhuis
Director, CAC

INTRODUCTION

After another year of expanding interest in climate issues, the variety of projects and accomplishments at the Climate Analysis Center (CAC) shows the value of a center with the mission to address near-real-time climate variations. Since there are now other groups who monitor and predict climate variations, perhaps it would be appropriate to emphasize the mission of CAC: "to define current climate anomalies and diagnose and predict them." However, our responsibility requires that our work also has application to agriculture, water resources, and energy.

The past year's highlights are listed below and a description of all projects is given in the text. It is necessary to maintain, however, that these achievements sometimes rest on several years of preliminary results. These accomplishments depend on an excellent technical and administrative staff whose dedication and support is implied in all that follows.

CLIMATE MONITORING

- Third Annual Climate Assessment - This publication provides a comprehensive review of the significant climate events of 1991. It highlights major climate anomalies as identified by the Climate Analysis Center, the National Climate Data Center, the Satellite Research Laboratory, and the NOAA Environmental Research Laboratories.

- 1991-92 ENSO Event - A number of ENSO Advisories were issued to provide authoritative information and guidance on the 1991-92 El Niño/Southern Oscillation (ENSO) to the national and international community of researchers, business, and decision makers. In recognition of this effort, the Department of Commerce's Silver Medal was awarded to members of CAC's ENSO monitoring and prediction team.

- Seasonal Climate Reviews - The quality of these reviews, published in the AMS Journal of Climate, was upgraded to a series of peer-reviewed papers.

- Climate Diagnostics Data Base - This comprehensive archive for gridded data was redesigned to accommodate data from the Climate Data Assimilation System, the Reanalysis Project and the Coupled-Model Project.

- Integrated North American Climate Advisories - CAC produced **North American Climate Advisories (92/1, 92/2)**, which blended in-depth information from 20 contributors for assessing current growing season conditions.

o Current Climate Assessment : CAC continues to distribute a number of climate-information products to Federal Agencies, state and local governments, international organizations and private industry. The publications include: **Weekly Weather and Crop Bulletin, Daily Weather Maps, Weekly Climate Bulletin, and the National Capital Summary - PRESTO.**

o Stratosphere - Ozone/Temperature: A temperature decrease since 1970 in the lower stratosphere has been established and is compared to observed ozone decreases in the same region. This is a major finding, since these elements taken together support the global extent of the phenomenon and the possible impact on the energy budget of the troposphere.

o Stratosphere - Aerosol: A weekly analysis of atmospheric aerosol content based on AVHRR data is now being made, in cooperation with NESDIS. Following the Mt. Pinatubo eruption, this product has been used extensively to track the aerosol and to aid scientists in examining effects.

o Stratosphere - Winter Bulletins: New hemispheric winter summaries were produced to provide selected indicators of stratospheric climate. This publication describes the ozone and temperature conditions of the past winter and places them into historical context.

CLIMATE SERVICES

o Information - A new Climate Information Delivery Service (CIDS) was developed from the previous Climate Dial-Up Service. The new system will have dial-up and network options, storage for complex data bases, and products for dissemination to many users.

o Agriculture - A new upgrade was made in the quantity and timeliness of products to USDA/JAWF. This now enables many NMC and CAC graphical products to be sent electronically to JAWF for briefings and publication applications.

o Stratosphere: Network for Detection of Stratospheric Change (NDSC) - The NDSC's Network Data Host Facility has been established at CAC. Initial efforts have focused on the utilization and intercomparison of NDSC data as an eventual replacement for meteorological rocketsondes. The CAC is the lead group examining available NOAA operational satellite information for evidence of possible stratospheric change.

o Regional Climate Centers (RCC) - The quality of the RCC Program was improved by establishing rigorous peer and site reviews, a visiting scientist program, 3-year Strategic Plans, and climate impact products on AFOS.

CLIMATE PREDICTION

- Winter Forecast- The 1991-92 winter was characterized by a number of exceptionally good precipitation Outlooks. The DJF precipitation forecast had a Heidke score of 30 (3 classes), an all-time record.

- Forecast Skill - In March 1992, the highest ever Heidke skill score was achieved for the 6-10 day temperature forecast. The scores for 3 and 5 classes were 42 and 30, respectively.

- Forecast Operations Security - An alleged security problem in the summer of 1991 was addressed and further improvements to the operations are being made as a result of improved hardware. Toward the long-term objective of modernizing access to resource materials for long-range prediction, major benchmarks have been reached in the automation of final map production, security, and product transmission.

- Long-Lead Forecasts - A methodology (CCA) is in place to produce long-lead forecasts. Also, the first Experimental Long- Lead Forecast Bulletin was produced in September 1992.

- DERF Experiment - The operational phase of the DERF Experiment produces routine runs out to ten days. This is the first use of Monte Carlo forecasting on an operational basis at NMC. A key element was the development of output displays of range and likelihood of possible forecasts. The production of daily forecasts out to 12 days is planned for December 1992.

- Ten-Year Run - A 10-year climate run of the NMC model is a data resource for subsequent research. Studies were conducted on: the frequency of blocking, large positive and negative anomalies, interannual variability, mass balance and the role of water, and the impact of soil moisture on monthly temperature and precipitation correlations.

- Advanced Model Intercomparison Project (AMIP) - A 5-year run of the NMC model was made to support the studies of the mass balance and the soil moisture interaction.

- Coupled - Model Evaluation - Collaboration has been started between CAC and the NMC/Coupled-Model Project on the evaluation of the design of coupled-model forecasts and their verification.

- Coupled-Model Climatology - A data base for the "climatology" from extended runs of the coupled model were compared to the Climate Diagnostics Data Base (CDDB) and ECMWF climatologies.

- Automation - The automation of the Outlooks has been accomplished, with plans for further improvements for the Second-Week, Monthly and Seasonal Outlooks.

ORGANIZATIONAL SUMMARY

In addition to the above activities, CAC scientists continued to conduct many climate research studies and document the results. The number of publications included 19 journal articles and 50 non-refereed papers (46 of the 50 also included a formal presentation). An additional 39 formal presentations were also made and 54 seminars were conducted.

Other CAC organizational activities included:

- Completion of a reorganization plan for a new Climate Prediction Institute (CPI) into a proposed National Institute for Environmental Prediction (NIEP). The proposed CPI has five branches that address NIEP's critical mission as NOAA's principle, central activity for operational prediction, environmental products, and services.

- Support for external research and development efforts at the U. of Maryland/CICS, UCAR, and the University of Chicago, as well as at the 6 Regional Climate Centers. There are also cooperative efforts with scientists from the following Universities: Colorado/CIRES, UCLA, Washington, Utah, Florida State and Alabama/Huntsville.

- Participation in the following National Programs: U.S. TOGA Panels, EPOCS, ESDIM, ASOS Steering Group, ASOS Climate Working Group, NOAA/Board of Directors of Global Change Program, OFCM/Committee on Wind Measurements and SOLRAD.

- Principal or co-principal investigators for the following Climate and Global Change Projects: Global Climate Perspectives System, Vegetation Index, Global Precipitation Climatology Project, Climate Data Assimilation System, Dynamic Extended Range Forecasting, Atmospheric Chemistry, Hydrological Cycle Project, and Soil Moisture and Long-Range Prediction.

- Support for the following NASA Programs: the Arctic and Antarctic Airborne Stratospheric Expeditions, the High Speed Aircraft Project, UARS, SAGE, ERBE, and CERES.

- Association with the following WMO Projects: Commission on Climatology, IAMAP, Network for Detection of Stratospheric Change, Science Working Group on Climate Change Detection, Climate System Monitoring Project, GEWEX/Continental International Project; CAS/Working Group of Rapporteurs on Climate; and Rapporteur for Climate Change.

- Participation in Bi-lateral Agreements: U. S. - Brazil and U. S. - Russian.

NOAA/NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER
CLIMATE ANALYSIS CENTER

MISSION

The mission of the Climate Analysis Center is to maintain a continuous watch on short-term climate fluctuations and to diagnose and predict them. These efforts are designed to assist agencies both inside and outside the federal government in coping with such climate-related problems as food supply, energy allocation, and water resources.

PRODUCTS

- Weekly Climate Bulletin
- Special Climate Bulletins
- Drought Advisories
- Climate Dial-Up Service
- Daily Weather Maps
- Precipitation Summary & Temperature Observations (PRESTO)

- Weekly Weather and Crop Bulletin
- Special Agricultural Bulletins
- Weekly Agricultural Assessment Briefings

- Global Stratospheric Analyses
- Global Ozone Analyses and Trends
- Stratospheric Summary (Northern/Southern Hemispheres)

- Monthly Climate Diagnostics Bulletins [real-time & delayed]
- Monthly Global Atmospheric/Oceanic Analyses
- ENSO Advisories
- Seasonal Climate Review Article [Journal of Climate]

- Six-Ten Day Forecast [Produced 3 times weekly]
- Monthly Outlook [Produced semi-monthly]
- Seasonal Outlook [Produced monthly]
- Experimental Long-Lead Forecast Bulletin

- Proceedings of the Annual Climate Diagnostics Workshop

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1. CLIMATE DIAGNOSTICS

1.1 Tropical Ocean/Atmosphere Interaction

1.1.1 Surface and Subsurface Oceanic Analyses (Smith, Chelliah, Ropelewski)

In this joint study (with R. Reynolds, NMC/Coupled Model Project), improvements were made in the analyses of sea-surface temperature (SST). Statistics for the optimal interpolation (OI) of SST were updated and implemented, based on one year of global observations. These measured statistics were used to perform an optimal average (OA) of historic SST from the Comprehensive Ocean Atmosphere Data Set (COADS). The OA produces a high-quality estimate of the SST, with confidence intervals that are proportional to the density and distribution of observations at any given time. The OA was run for different sub-areas which could then be combined into larger areas. The OA was also run using different first guesses, as well as corrected and uncorrected SST observations.

The OI was also run for COADS seasonal data; but instead of using the COADS SST, a value of 1.0 was inserted where there was an observation and the first guess was made 0. The OI analysis shows areas of good data distribution for an optimum analysis by returning values close to 1 where the sampling was dense and values of 0 where the sampling was sparse. Both the OA and the OI between 0 and 1 give estimates of errors, with the OA more quantitatively accurate, and the OI showing more precise data density. The global OA (**fig. 1**) shows both ENSO time-scale variations and lower frequency variations. The standard deviation error indicates that during both World Wars I and II, data density decreased significantly. Much of the cooling from 1900-1940 is significantly different from zero, as is the warming in the 1980s.

In a related study, an evaluation was made on the monthly reanalyses (generated by the NMC/Coupled Model Project) of tropical Pacific Ocean temperatures. The reanalyses was for the July 1982 to May 1992 period which includes two strong warm events and one strong cold event. This examination revealed significant temperature variations with depth, as shown by the 100m standard deviation (**fig. 2**). Variations near 10N in the Pacific Ocean are noteworthy, as they imply that there are variations in the thermocline depth along that latitude, which are related to the strength of both the north equatorial current and counter current. Also, an empirical orthogonal function analysis has shown the evolution of temperature variations for the three-dimensional ocean volume.

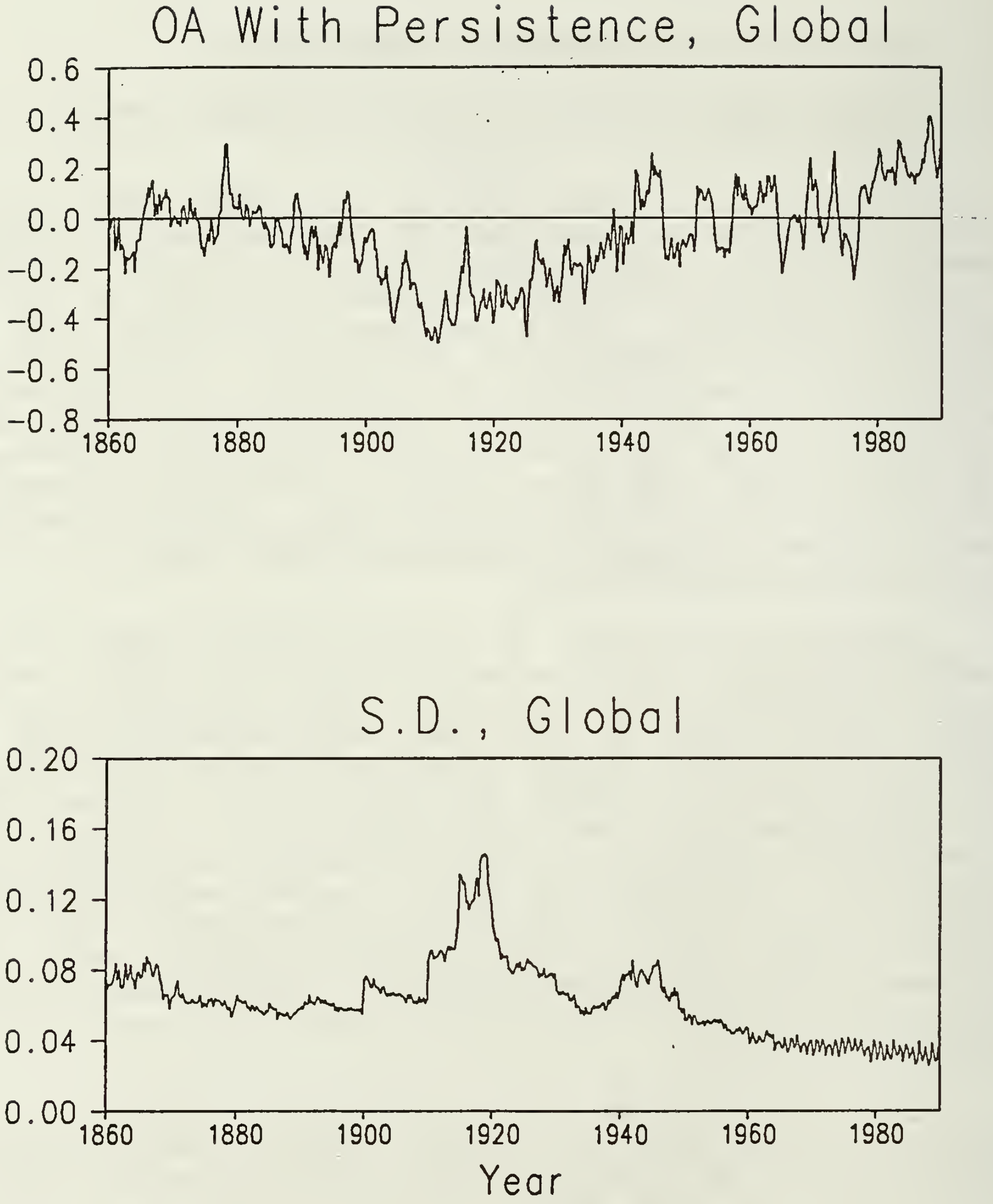


Figure 1: Globally-averaged COADS SST anomalies (top and the standard deviation of the error (bottom) measured using the OA (both in units of °C). The error in standard deviation can be used to define confidence intervals based on the sampling density and distribution, assuming that errors are normally distributed.

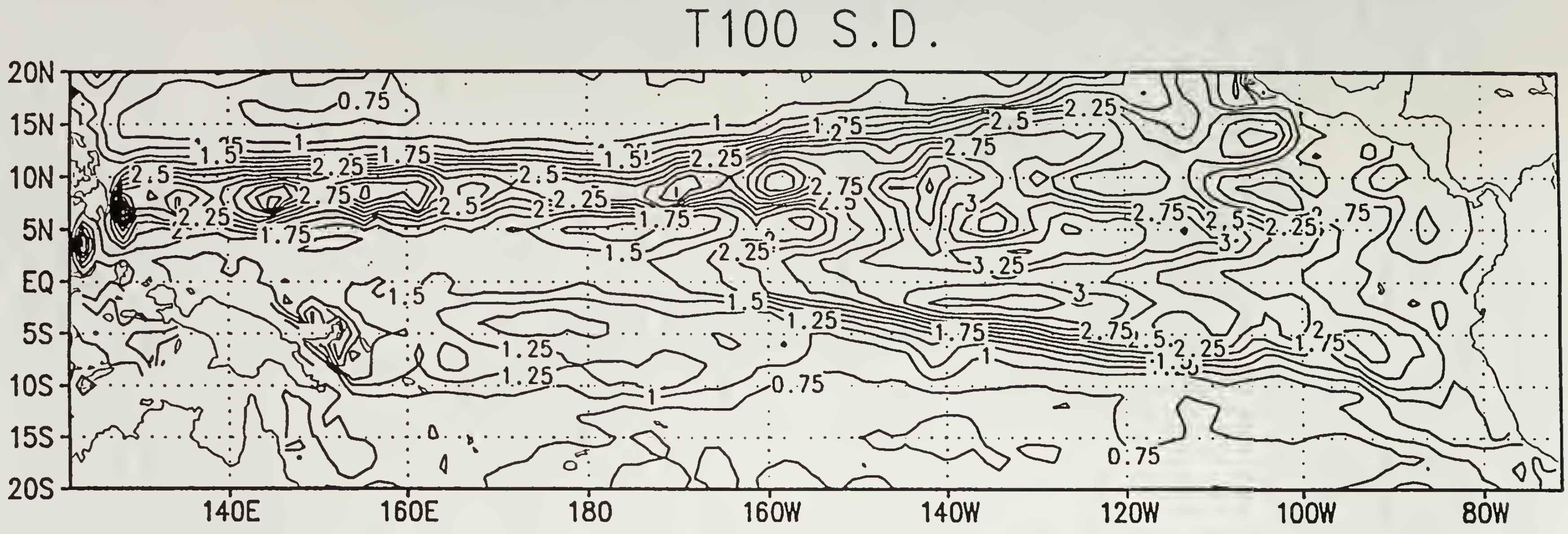


Figure 2: Standard deviation of 100m ocean temperature between 20°N-20°S in the Pacific Ocean, from monthly NMC analyses (1982-1992). Isotherm interval is 0.25°C.

1.1.2 Ocean/Atmosphere Coupling (Kousky)

The primary goal of this project is to increase the understanding of the evolution of the Southern Oscillation in the ocean/atmosphere coupled system. Principal modes were computed of the near-global outgoing longwave radiation (OLR) and 250 mb circulation which are associated with interannual variability related to the El Niño/Southern Oscillation cycle. The results show that the dominant mode is associated with extremes of the Southern Oscillation and closely related to extremes in the sea-surface temperature anomaly pattern. These findings were described in two joint papers (one with K. Mo and one with M. Kayano) that were submitted for journal publication.

1.1.3 ENSO Prediction (Ropelewski, Halpert)

The goal of this study is to quantify the relationships between precipitation and the extremes of the Southern Oscillation. Precipitation limits that are required for the 10, 30, 50, 70, and 90th percentile during warm and cold events were determined for core regions of the Pacific Ocean, South America, and the U. S. Gulf Coast (**fig. 3**). Preliminary results show that the median precipitation amount in the base period often falls in the 30th or the 70th percentile during either warm or cold event years.

1.1.4 Coupled Model Diagnostics (Chelliah, Smith, Ropelewski)

In this study, monthly mean climatologies of pressure level and surface flux quantities were computed from a 10-year atmospheric run (made by the NMC/Coupled-model Project). These mean climatologies included: sea surface temperature, ocean temperature at 100- and 200- meter depths, longitude-depth cross-section of ocean temperature at the equator, and latitude-depth cross section at longitudes 165E and 110W. In addition, means and departures from the annual mean were computed to produce a good representation of the mean ocean temperature structure. An extended, rotated joint principal component analysis was then completed for the six quantities (mentioned above). The results give the spatial and temporal evolution of the mean annual cycle (1st harmonic) and the semi-annual cycle (2nd harmonic) for the tropical Pacific Ocean temperature. Although the evolution of the annual cycle of the Pacific SST has been well documented, the details of the evolution of the sub-surface temperature fields are not as well known.

Analyses were also performed on the ten-year monthly mean fields for the same 6 quantities to examine the evolution of the low-frequency variability in the ocean temperature structure. Preliminary results, for Pacific Ocean temperature fields, show that the variance associated with the interannual low-frequency variability is about as large as that associated with the

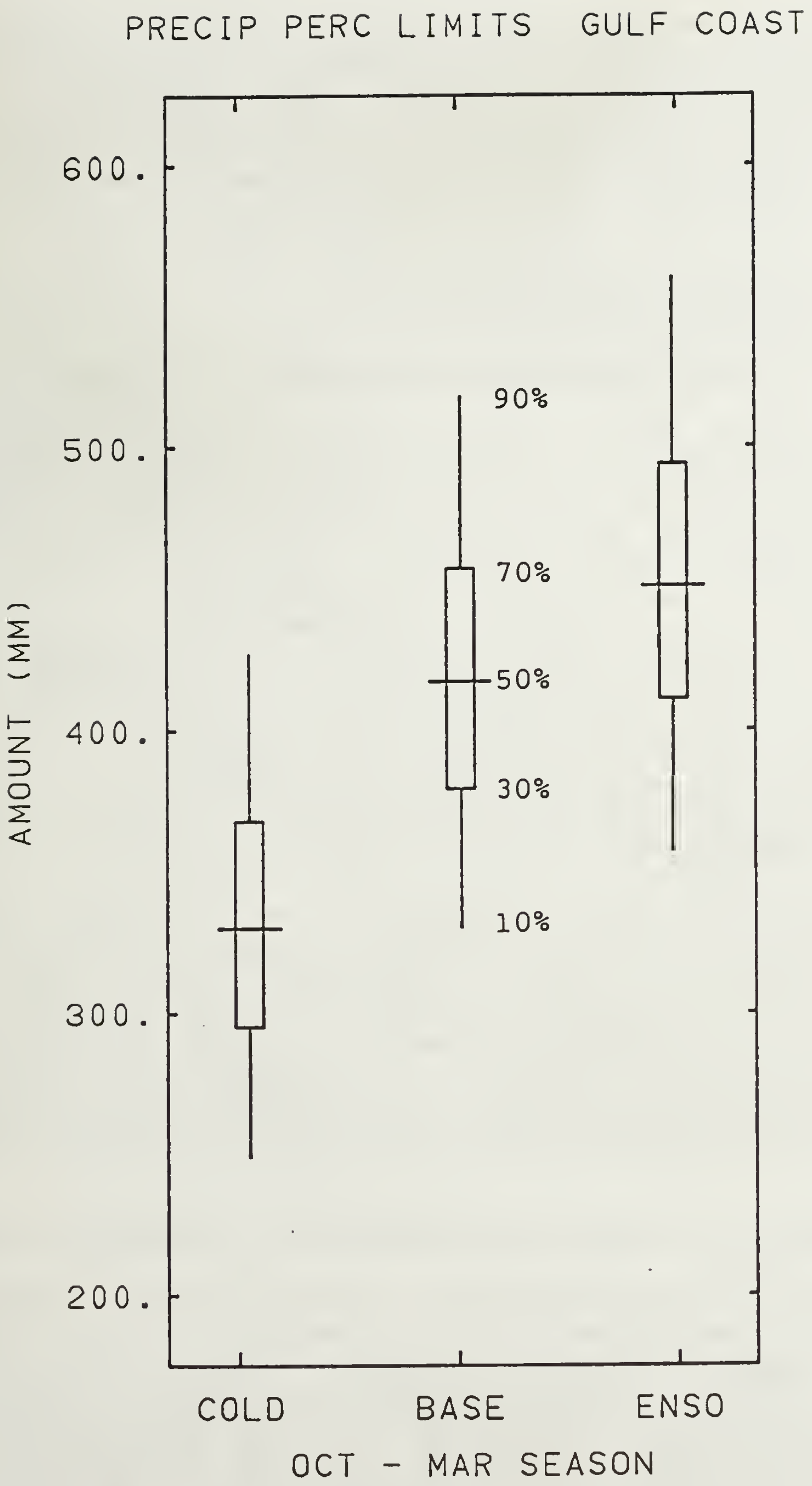


Figure 3: Precipitation percentile limits for the 1961-1990 base period, warm event years and cold event years. The horizontal line represents the 50th, or median, precipitation amount. Each "box" delineates the precipitation amount required for the 30th and 70th percentile while the "whiskers" lines delineate the 10th and 90th value.

seasonal march of the annual cycle. Monthly standard deviations of these fields were computed, with the highest values of standard deviation (more than 3.25°) found at the 100 meter depth. In the longitude-depth section along the equator, the maximum standard deviation was at the 125m depth near 140°W, where coincidentally the east-west slope of the thermocline is also at its maximum.

1.2 Circulation Diagnostics

1.2.1.1 Tropical Convection/Atmospheric Circulation (Kousky)

A joint study (with M. Kayano, Brazil) was completed on the principal modes of OLR and 250 mb circulation for the South American sector. By filtering the data prior to computing the EOF patterns, those modes associated with interannual variability were effectively separated from those associated with intraseasonal variability. The interannual modes primarily reflect the major swings in atmospheric circulation and convection related to the extremes in the Southern Oscillation (SO). The first combined mode (**fig. 4**) contains all of the major circulation and precipitation features that have been found to be associated with the extremes of the SO. The analysis also revealed important seasonal characteristics of the ENSO-related circulation features. A manuscript, which describes these results, was submitted for journal publication.

A related study was conducted on the global modes of OLR, 250 mb circulation, and sea-level pressure. Preliminary results show a near-global pattern of sea-level pressure (SLP) anomalies associated with anomalous OLR and 250-mb circulation patterns. This is consistent with the pressure variations associated with the extremes in the Southern Oscillation (SO). By projecting SLP, OLR, and 250-mb winds on to the SO modes, one obtains time series similar to the Tahiti-Darwin Southern Oscillation Index.

1.2.1.2 Tropical Convection/Atmospheric Interaction (Mo, Kousky)

Tropical-extratropical connections are being investigated for 250 mb streamfunction anomalies in both intraseasonal to interannual frequency bands. The principal modes of anomalous 250 mb streamfunction were computed and related to anomalous outgoing longwave radiation (used as a proxy for deep tropical convection). Singular spectrum analysis was performed to examine the dominant oscillatory modes associated with each principal component (PC) of rotated EOFs. Results show that the leading EOF mode for both the NH winter (**fig. 5a**) and summer has large zonal components and displays many features associated with low-frequency climate anomalies related to the Southern Oscillation. Also, the time series of the PC associated with this mode displays a large amount of variability at shorter time scales, with features consistent with the 30-60 day oscillation.

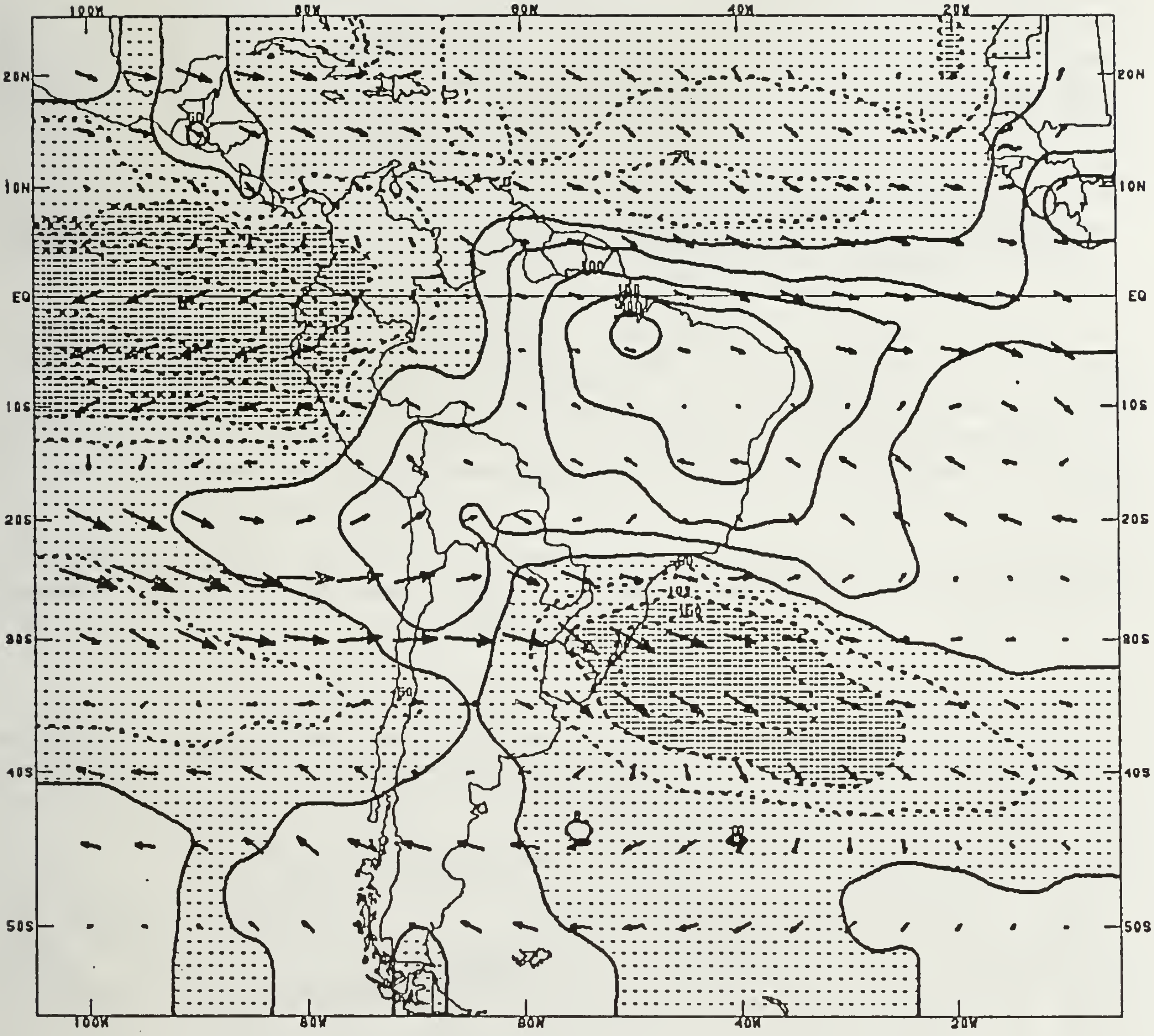


Figure 4: The first combined (outgoing longwave radiation and 250 mb vector wind) rotated EOF for the interannual band. The loadings for OLR anomalies are contoured with positive (negative) loadings indicated by solid (dashed) lines. Light (dark) shading indicates relatively weak (strong) negative OLR loadings. Vectors are proportional to the amplitude of the 250 mb wind vector loadings.

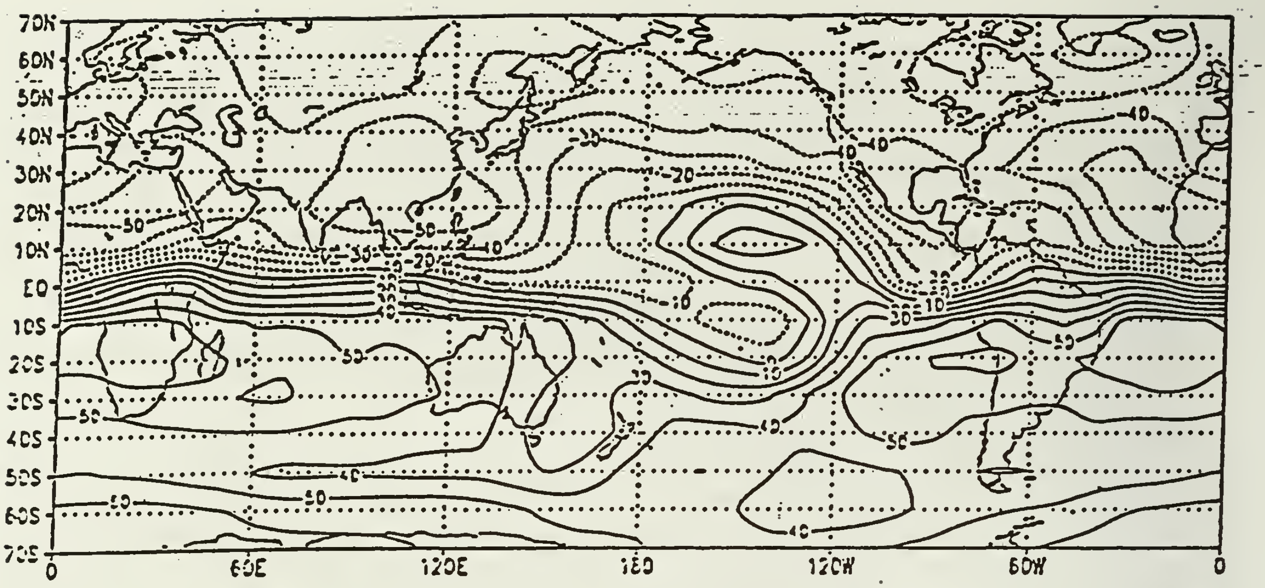


Figure 5 (a): Spatial EOF 1 pattern of 250 mb streamfunction anomalies for December, January and February. Contour interval is 10E-03. Negative contours are dashed.

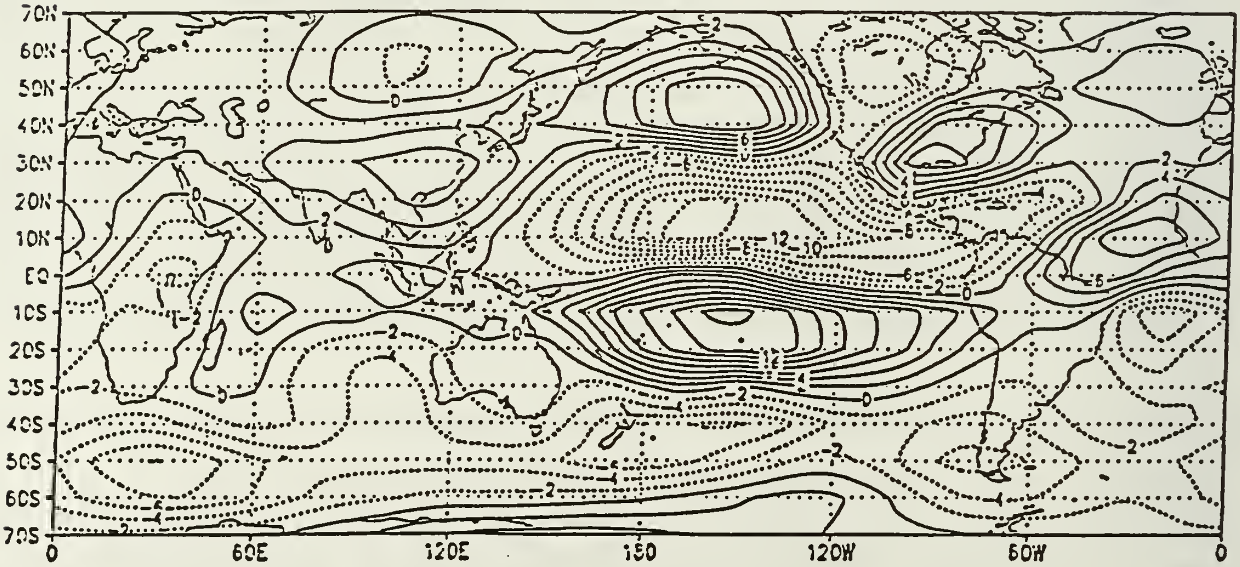


Figure 5 (b): Same as figure 5a, but for the second dominant pattern during December, January and February.

The second dominant mode for the NH winter is related to the tropical-extratropical divergence anomaly zones in the Northern Pacific. The pattern (**fig. 5b**) consists of a wavetrain from the Pacific Ocean eastward across North America and then over the Atlantic Ocean. The interannual variations of this mode are related to the tropical convection. Intraseasonal variability of this mode is shown to be related to variability in moisture bursts (cloud bands) in the North Pacific. The leading pattern is also associated with the Asian monsoon variability during June, July and August.

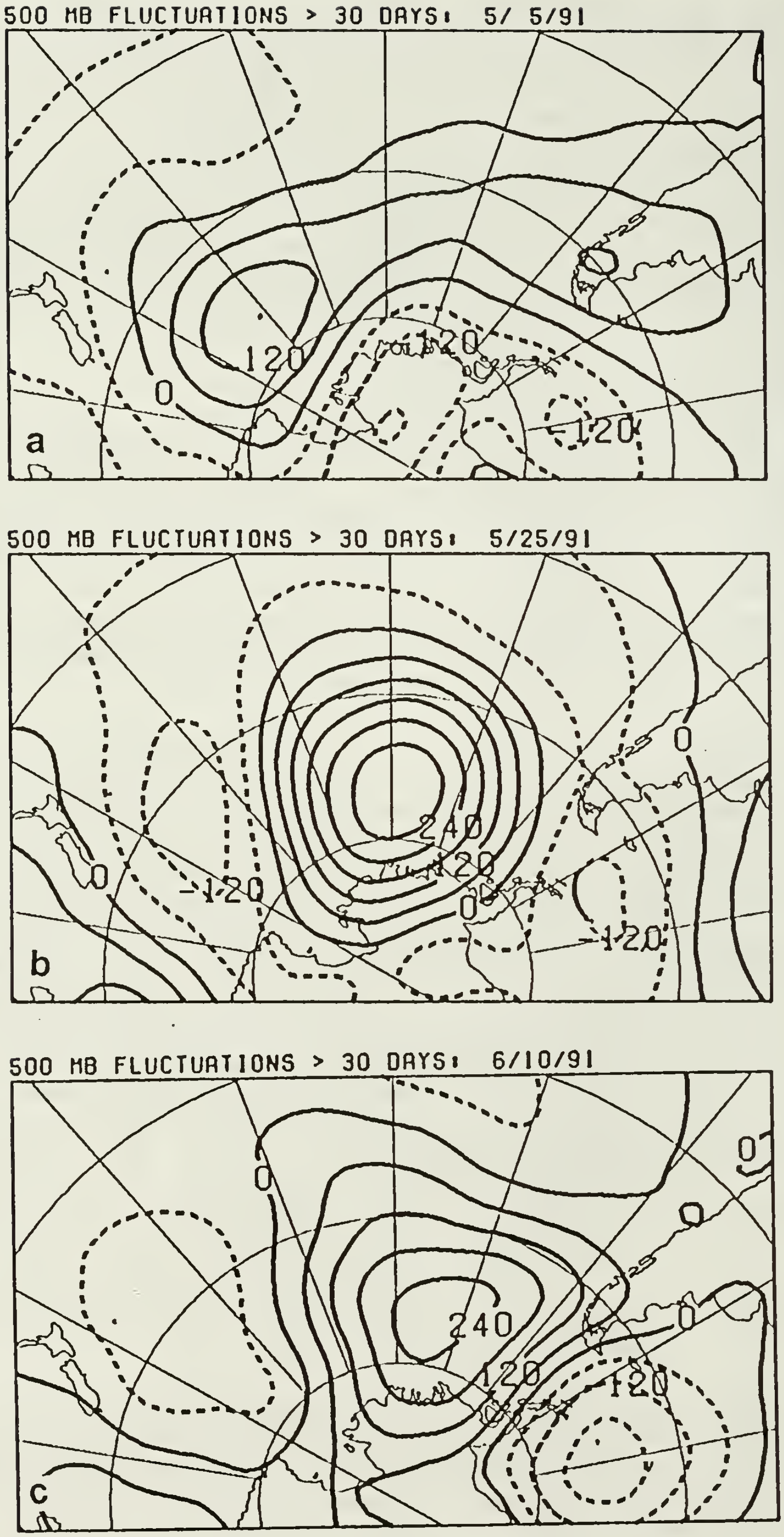
1.2.2 Extratropical Circulation (Bell)

Two studies were conducted on the medium and short-term climate variability in the extratropics. The first one involved an examination of the structural evolution of mid-tropospheric cutoff cyclonic circulations over the eastern United States. The results of this study were jointly written (with D. Keyser and L. F. Bosart, SUNY) and submitted for journal publication. The second study involved research into the structure and evolution of circulation anomalies in the extratropics which persist for periods in excess of one month.

A related task focused on investigating the evolution of a major blocking episode over the high latitudes of the South Pacific. One important finding is that long-lived circulation anomalies can sometimes exhibit a well-defined life cycle (**fig. 6**) which resembles that of a baroclinic wave during baroclinic wave evolution and reflects energy propagation through the anomaly on the inter-monthly time scale. **Figure 6a**, for example, shows that the flow pattern is highly asymmetric about the ridge axis 20 days prior to maximum ridge intensity. The flow then becomes increasingly symmetric about the ridge axis, as the anomaly reaches maximum intensity (**fig. 6b**). During the next 15 days, the strongest meridional flow becomes established downstream of the mean ridge position (**fig. 6c**). This evolution appears to reflect the propagation of the jet through the mean ridge axis, with maximum ridge intensity coinciding with the period when the jet is centered within the ridge crest. Then, the ridge weakens as the jet moves downstream toward the trough.

1.2.3 Climate Model Diagnostics (Mo, Wang)

A study was made on the coupled-model climatology (11-year integration, 1982-1992 that was developed by the NMC/Coupled Model Project). Preliminary results show that the model produces realistic standing waves in the Northern Hemisphere, but weak stationary waves in the Southern Hemisphere. The model also captures the most important seasonal changes at 1000 mb and 500 mb. In addition, zonally-averaged tropospheric temperatures show a 1-4 degree cold bias, while stratospheric temperatures over the South Pole show a bias as large as 18°K.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c

Figure 6: Southern Hemisphere: Low-pass filtered (30-day low pass filter) height anomalies valid (a) 5 May 1991, (b) 25 May 1991, and (c) 10 June 1991. Contour interval is 60 m.

In the tropics, it was found that the model can simulate ENSO-related features, as indicated by the streamfunction and divergence at 200 mb. A comparison was made between the first EOF for the 200-mb streamfunction from NMC analyses (**fig. 7a**) and from the model-simulated data (**fig. 7b**). The results indicate that the model captures the zonally-symmetrical components and the dipole in the Pacific related to the ENSO events. The principal component (PC) associated with the first EOF shows that the model also captures the low-frequency variability very well (**fig. 7c**). Although the model produces an intraseasonal oscillation, the speed of 25 days is too fast.

1.2.4 Climate Data Assimilation System/Reanalysis (Mo, Wang)

A comparison was made between the analyses produced by the T126 and T62 models to decide which one would be used for CDAS/Reanalysis. The two models are the same except for different horizontal resolutions. A diagnostic study was performed on pressure, sigma, and surface files from the two models for May 1992. Results show that the major differences in pressure files are in the Southern Hemisphere At high latitudes, the circulation from the T62 model is weaker. In the stratosphere, the T126 model produces lower temperatures (1-2^{o}C) at high latitudes and a stronger wave 1 feature. Other differences in surface and sigma files are orographic-related, as lower-level winds near mountains cause differences in the moisture fluxes and divergence. Over South America, the T126 model (**fig. 8a**) produces more rainfall than the T62 model (**fig. 8b**); however, both models capture patterns very well (**fig. 8c**).

1.2.5 Tropical Rainfall (Janowiak)

Geostationary satellite data from the GPCP are available every 3 hours and were used to study the diurnal character of rainfall in the tropics during the 1986-90 period. As expected, the diurnal effects are strongest over the continental regions, where the preferred time of convection appears to be between 1800-2100 local time. This result appears to be independent of the cloud-top temperatures that are used to define convection (235-, 225-, and 215K). However, more intense convection (as inferred from 225K and 215K temperatures) indicates a preferred maximum over the oceanic regions during 0300 - 0900 local time. This time varies substantially with the cloud-top temperature.

Results from this study also indicate a simultaneous out-of-phase relationship between oceanic and continental deep convection over the course of the day in the tropics (**fig. 9**). It appears that the Atlantic ITCZ is at its weakest when convection over Africa and South America is near its daily peak time (1800 - 2400 UTC). Conversely, the Atlantic ITCZ is at its strongest when African and South American convection is at the daily minima time (0600-1200 UTC time).

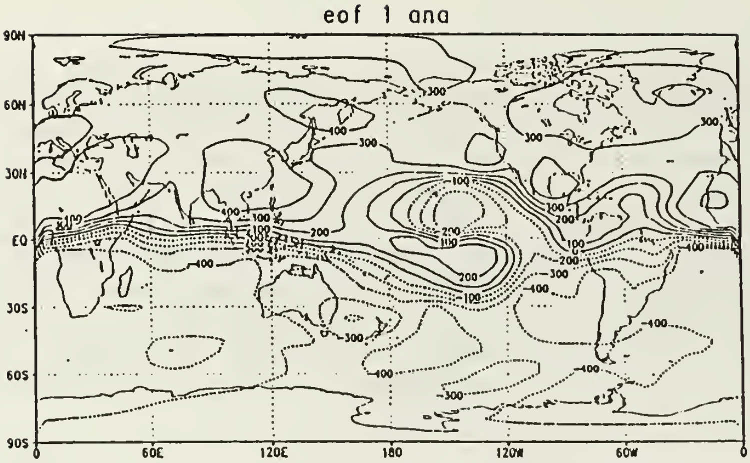

Figure 7 (a): The first EOF for 200 mb pentad streamfunction field from the NMC analyses for 120 months (1982-1991). Contour interval is 100.

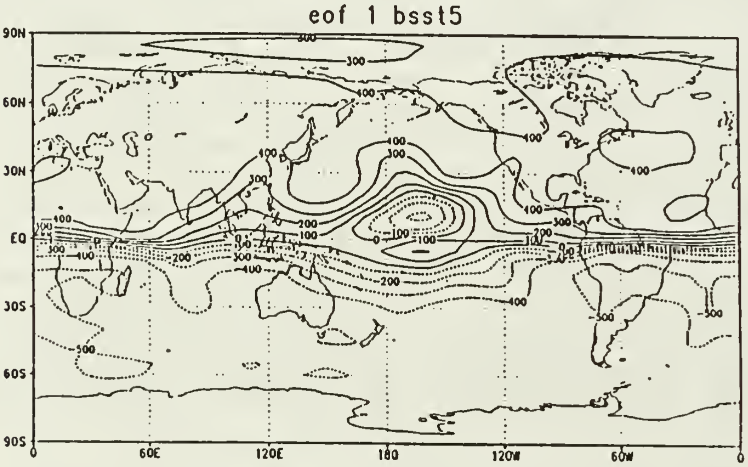

Figure 7 (b): Same as 7a, but for model-simulated data.

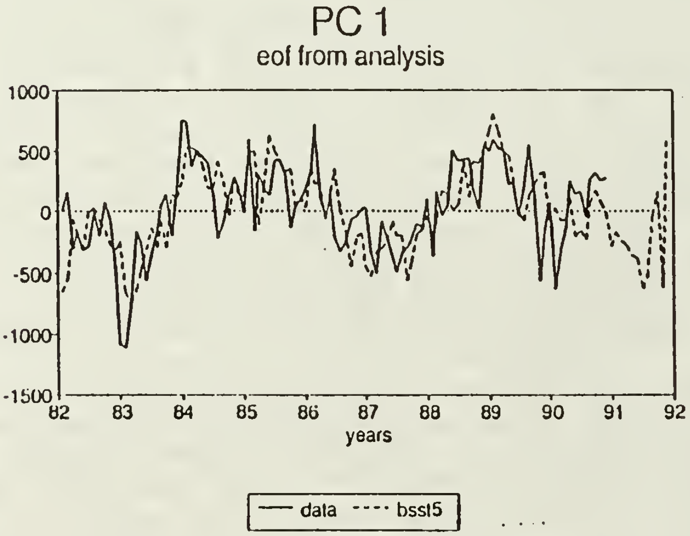

Figure 7 (c): PC 1 associated with EOF 1 (fig. 7a) for model outputs (dashed) and analyses (solid).

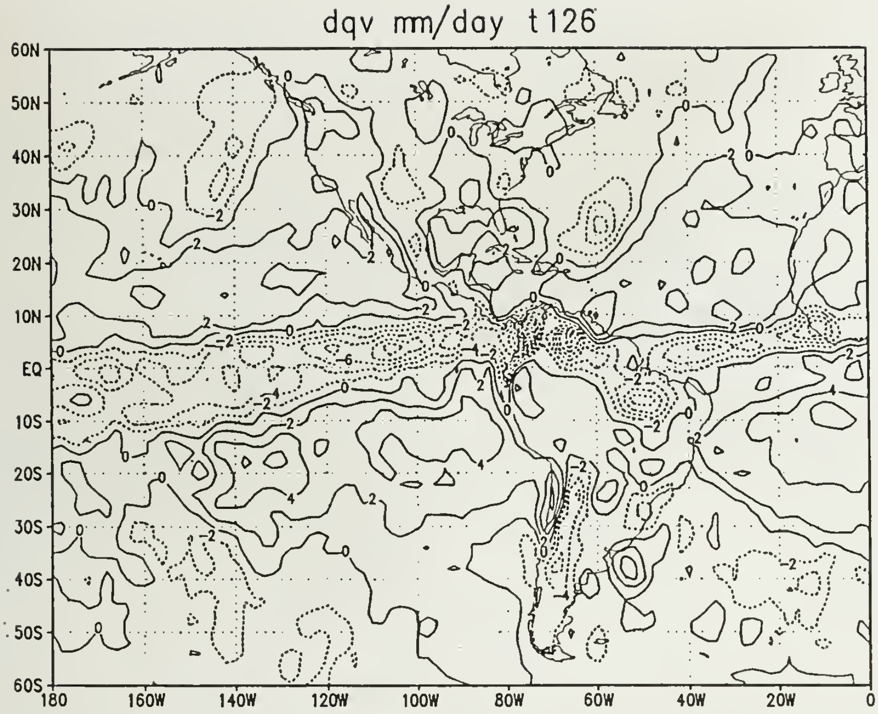
dqv mm/day t126

Figure 8 (a): The moisture divergence D(qv) for May 1992 from the T126 model. Contour interval is mm/day.

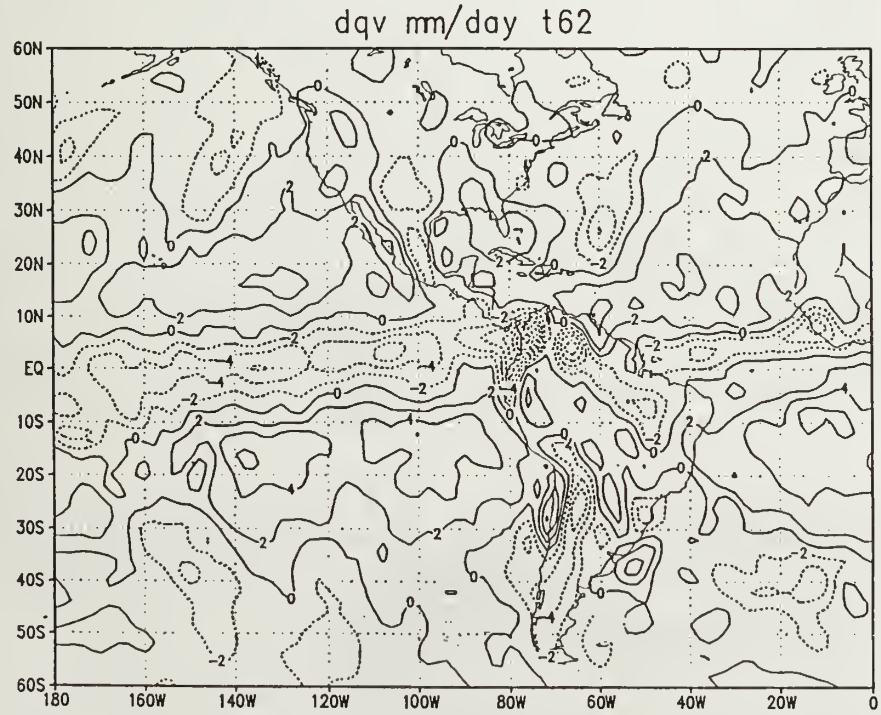
dqv mm/day t62

Figure 8 (b): The moisture divergence D(qv) for May 1992 from the T62 model. Contour interval is mm/day.

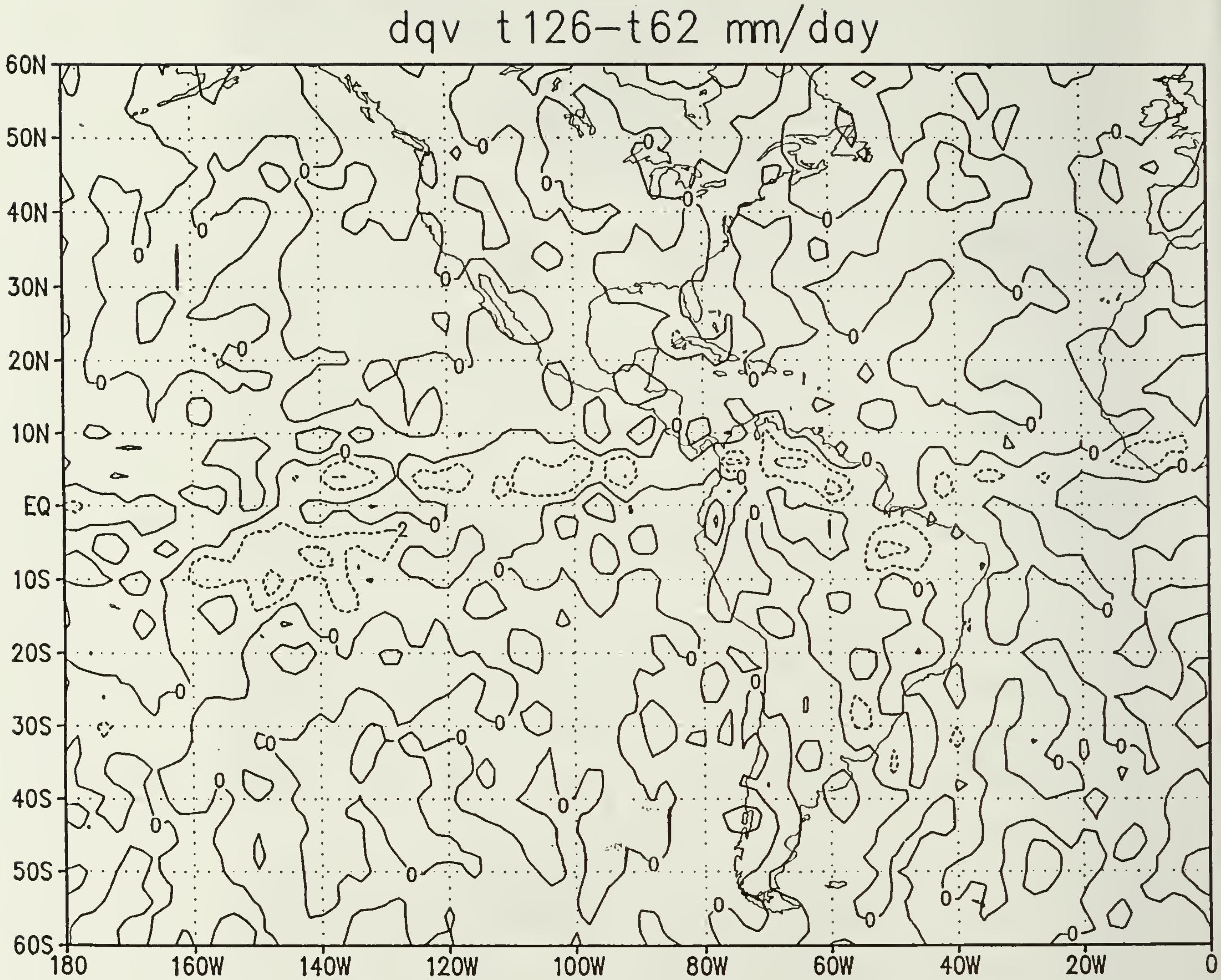

Figure 8 (c): Differences between the two models (T126 and T62) in moisture divergence D(qv) for May 1992. Contour interval is mm/day.

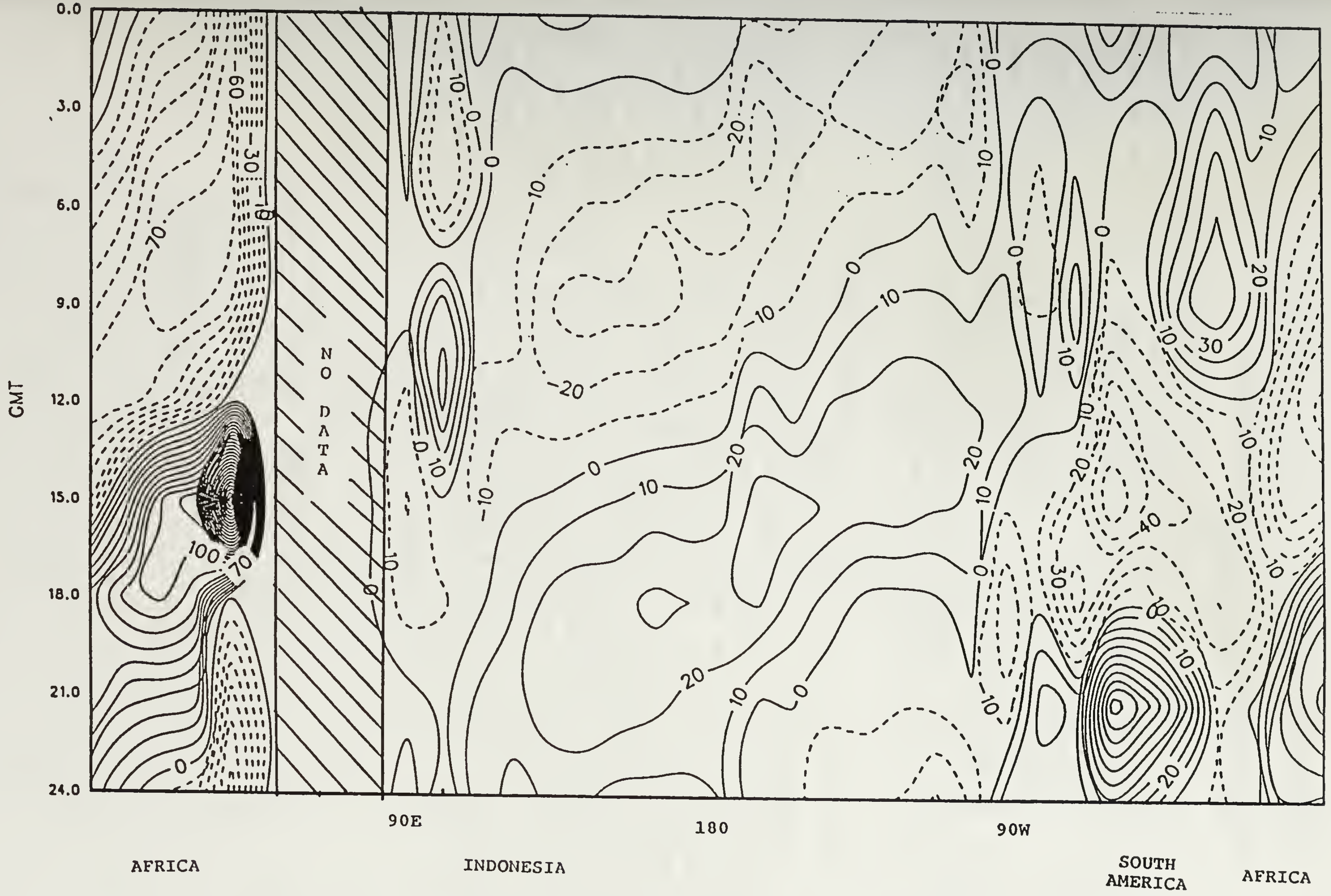

Figure 9: Time-longitude plot of the percent departure from the daily mean (1986-90) for the fractional coverage of cloud < 215K for the zonal band $20^{o}N-20^{o}S$ over the period 1986-90. The solid (dashed) lines indicate above (below) the daily mean. Contour interval is 10%.

1.3 Hydrological Studies

1.3.1 North American Land Surface/Atmospheric Hydrologic Cycle (Janowiak, Ropelewski)

A new upper-air archive is being generated for two separate data sets. One set contains monthly-averaged global rawinsonde observations and the other contains basic parameters and derived products over North America for pentad and monthly periods. Both archives will store the 0000 and 1200 UTC observations separately and will include wind components, height, surface pressure, temperature, and specific humidity. In addition, the North American archive will contain daily cross-products of the wind components with temperature and specific humidity, as well as potential temperature and energy terms. **Figure 10** depicts the typical spatial resolution of the rawinsonde observations over North America.

1.3.2 Model-Based Hydrologic Cycle Studies (Mo)

Implementation of the GDAS-T126 system has resulted in operational and forecast products that help improve the global description of the atmospheric branch of the hydrological cycle. Monthly mean analyses and forecast fields have been critically examined for the first year (June 1991-July 1992). Comparisons were made with satellite estimates of rainfall and conventional data over the tropics. Figure 11 shows a time-latitude cross-section for monthly-averaged zonal mean rainfall from 0-6 hr. forecasts (**fig. 11a**), 12-36 hr. forecasts (**fig. 11b**), and the climatology from the GPCP Project (**fig. 11c**). All depict the migration of rainfall maxima from the Southern Hemisphere during JFM to the Northern Hemisphere during JJA. The differences uncovered, so far, are small and could be due to interannual variability. These results are encouraging and the consistency of the annual cycle is now being examined for selected regions.

12Z, DEC. 1 to 31, 1989

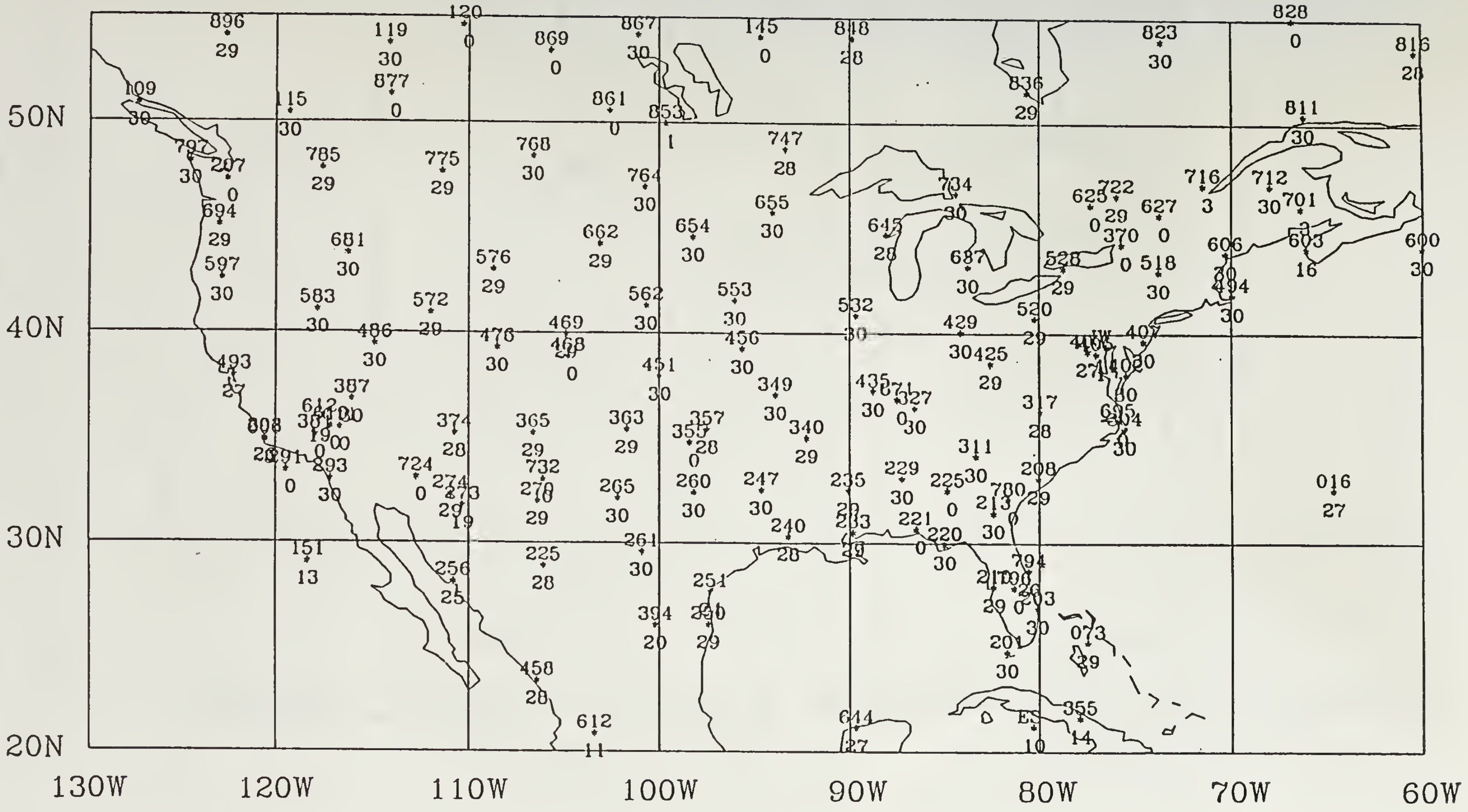

Figure 10: Distribution of rawinsonde reports over North America for December 1989 at 1200 UTC. At each station, the top number is the last 3 digits of the WMO block/station number, the bottom value is the number of observations for the month.

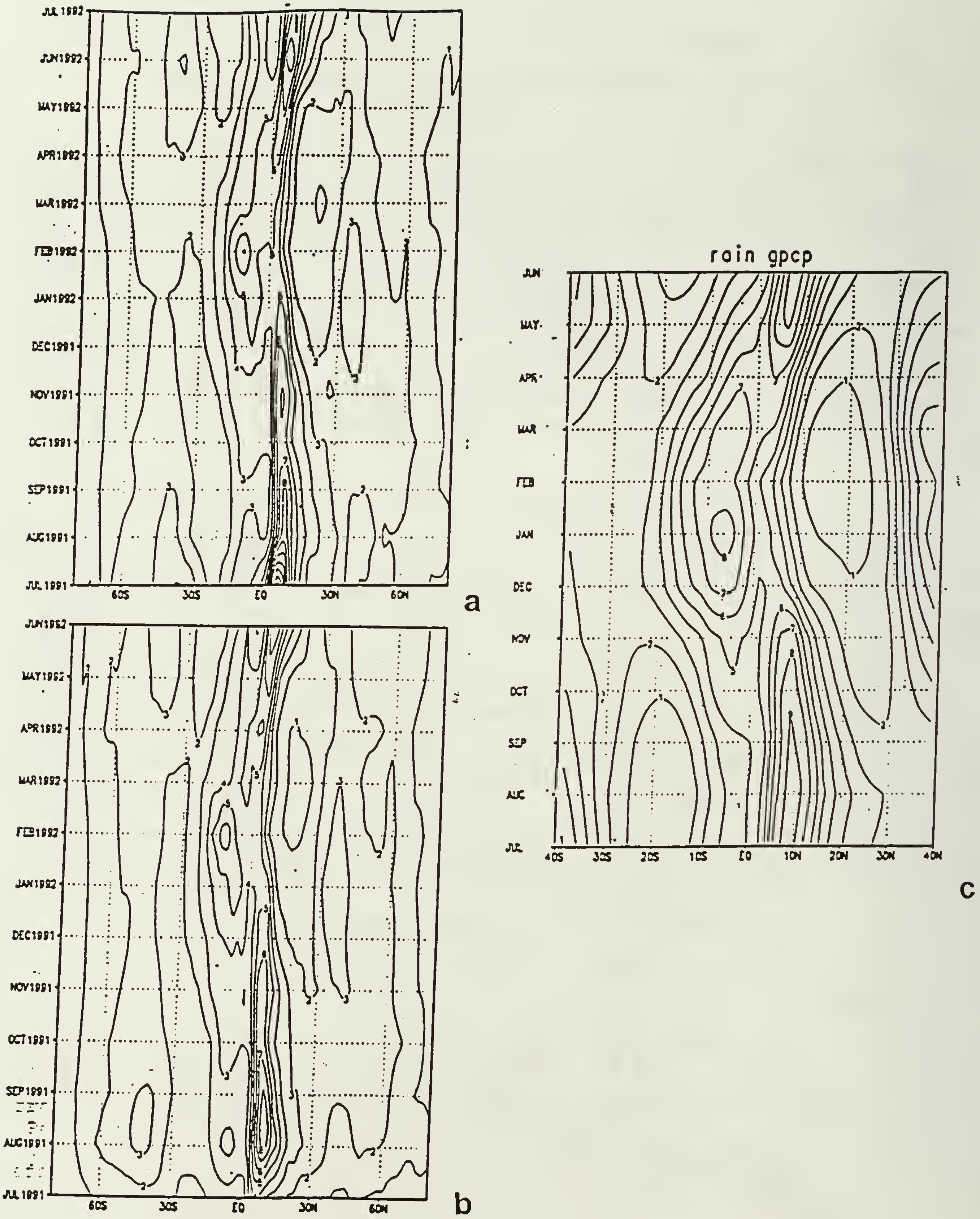

Figure 11: Hovmuller diagram for monthly-averaged zonal mean rainfall from (a) 0-6 hr. forecasts, (b) 12-36 hr. forecasts, and (c) GPCP climatology. Contour interval is mm/day.

2. CLIMATE ANALYSIS

2.1 Surface Climate

2.1.1 Surface Climate Anomalies (Halpert, Ropelewski, Garrett)

CAC scientists continued their participation (with (personnel from other NOAA/Line Offices) in the development of the Global Climate Perspectives System (GCPS). As part of this project, reliability statistics were computed for various stations during the 1980's. For any one year, about 90% of the stations with historical records have received temperature data at least 50% of the time and 75% of the stations have received precipitation data at least 50% of the time. Statistics were computed that have been valuable in the selection of reliable reporting stations for use in a real-time monitoring effort.

2.1.2 Climate Change Studies (Halpert, Ropelewski)

A diagnostic study was initiated to identify the predominant surface temperature patterns during the December-May period from 1951-1992. Results showed that during the 1980's, the dominant temperature pattern exhibited large positive anomalies over central and western Russia and northwestern North America, with large negative anomalies over Greenland and Baffin Island. Rotated empirical orthogonal functions were computed and **figure 12** shows the time series and the spatial loading patterns for the leading mode of this period. The explained variance is given at the top right corner of the corresponding loading function. The first mode shows a strong resemblance to the pattern observed during 1981-1990, especially over central Russia. However, the temperature centers over northwestern North America and Greenland during the 1980s appear stronger in the fourth and second mode, respectively (not shown).

2.1.3 Snow/Ice Monitoring (Garrett)

A recomputation is being performed at CAC on the satellite-derived snow-cover data (NESDIS) from 1966 to the present. This recomputation is based on a consistent land/sea mask and date scheme and is being run parallel with the processing by NESDIS. When the CAC method is determined to be working properly, it will replace the current (NESDIS) snow-area calculation procedure. One example (**fig. 13**) shows seasonal time-series plots, based on the CAC procedure which slightly modified the current operational NESDIS product. In addition, the large-scale relationship between the temperature and snow cover anomalies continues to be monitored (**fig. 14**).

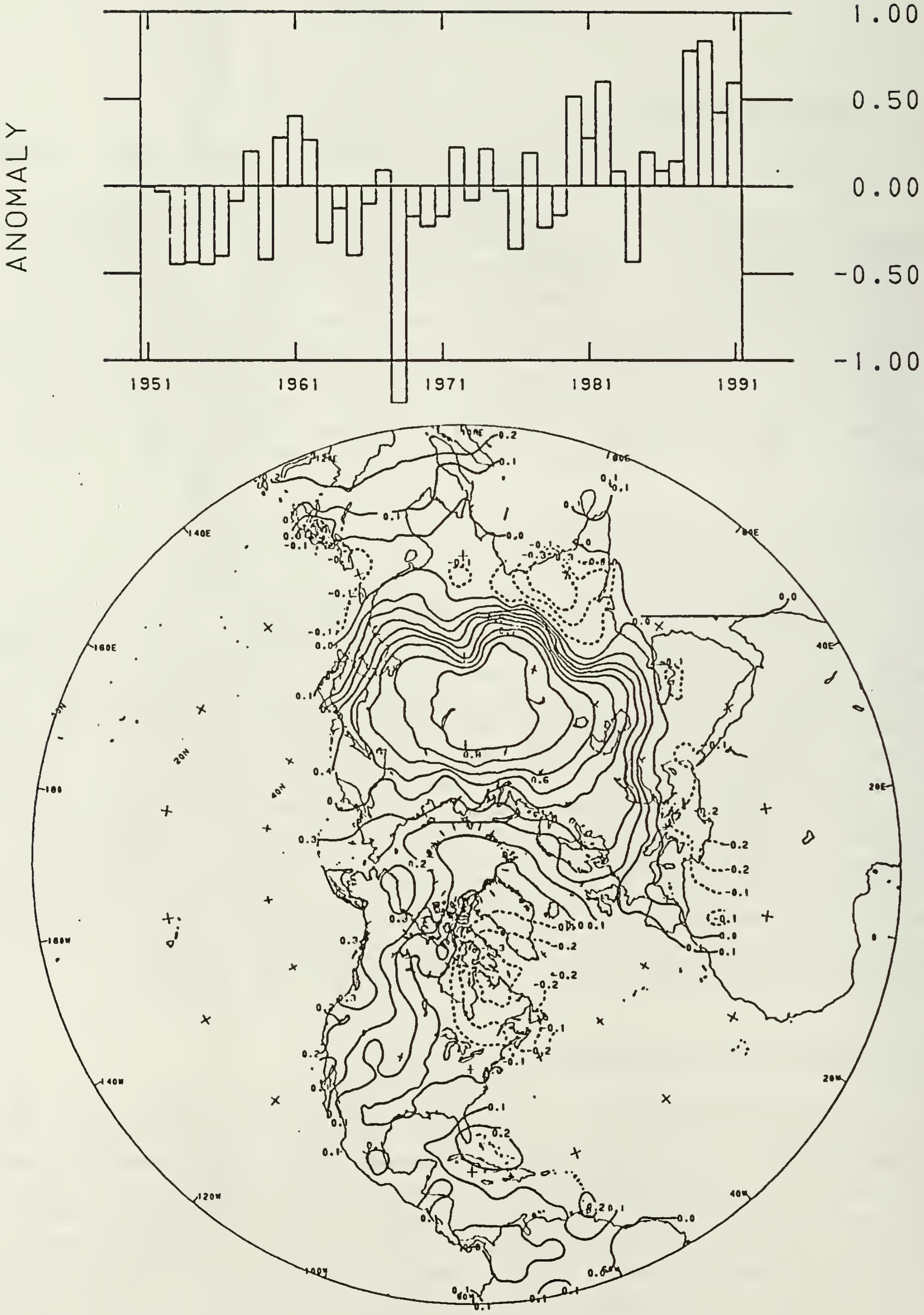

Figure 12: The time series and the spatial loading pattern for the leading empirical orthogonal function of the Northern Hemisphere (excluding Africa) December - May temperature anomalies from 1951- 1992.

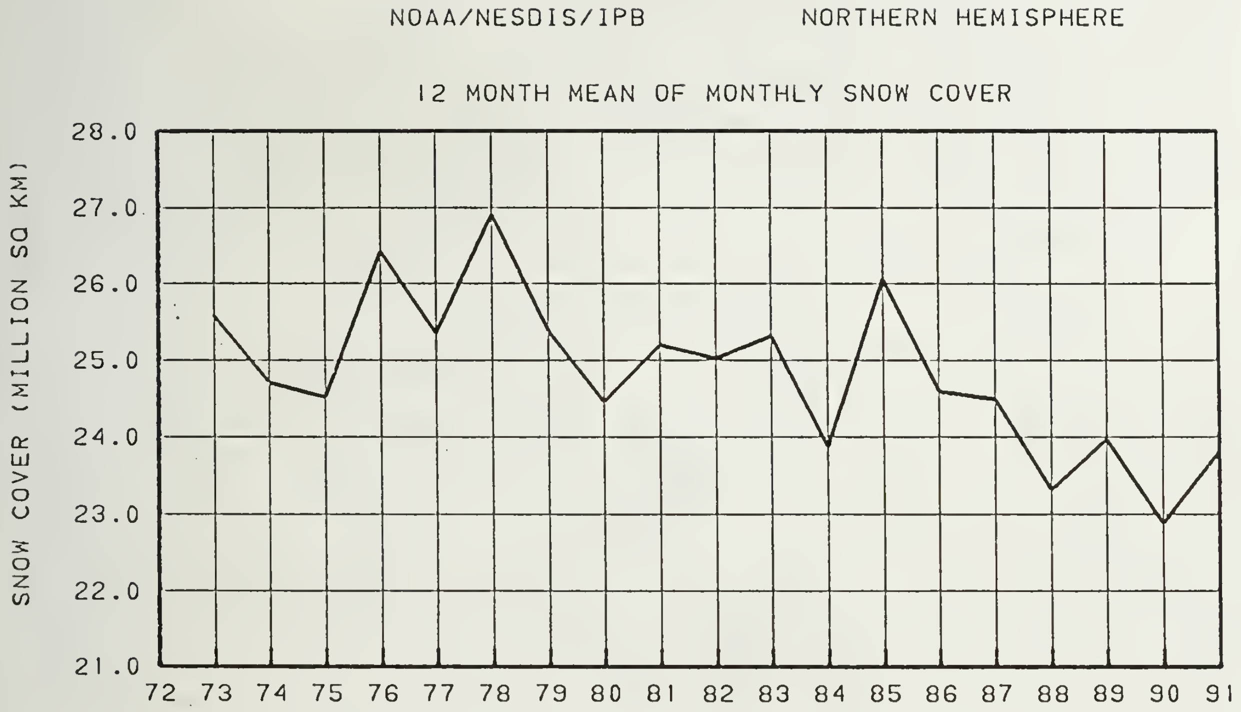

Figure 13: The monthly mean snow cover averaged over one year for the Northern Hemisphere during the period 1973 - 1991.

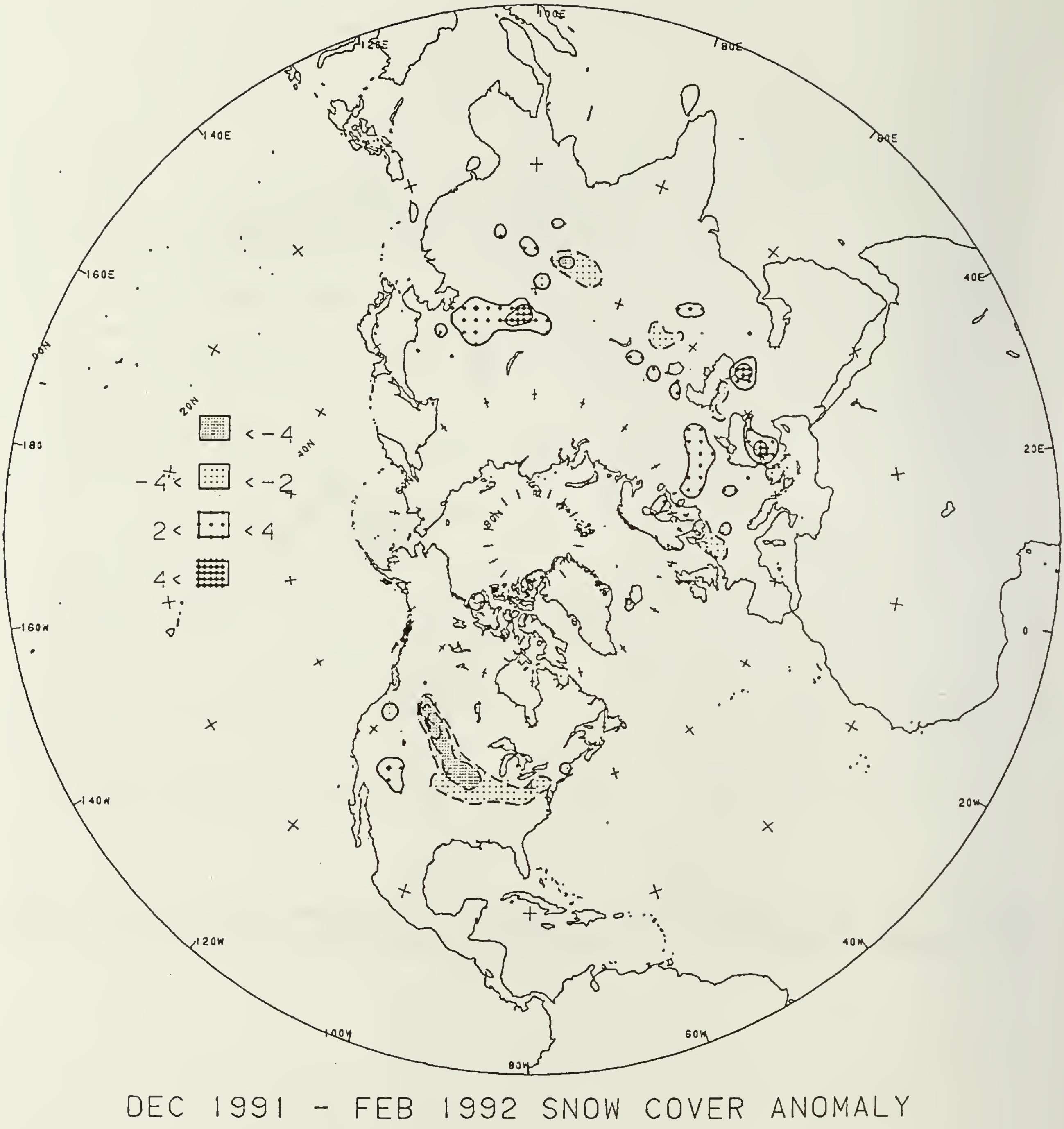

Figure 14: Northern Hemisphere Winter (1991-1992) snow cover anomaly using 1973-1992 as the base period mean for the DJF season. Negative (Positive) differences indicate snowfall deficit (abundance).

2.2 Satellite - Derived Climate Products

2.2.1 Global Precipitation Climatology Project (Janowiak)

An examination is being made of the discontinuities among the geostationary and polar orbiting satellite IR data to determine the reasons for these differences. Rainfall estimates from NOAA-11 have been found to be consistently higher than the corresponding geostationary estimates and those from NOAA-10. This was determined by comparing "time-matched" estimates from each geostationary satellite and the NOAA-10 and NOAA-11 polar orbiting satellites (**fig. 15**). Only appropriate geostationary observations times were used at each location that matched the polar orbiting observation times (within 1 hour) to ensure a matched sample. Interestingly, since the OLR data stream went from NOAA-10 to NOAA-12, the rainfall estimates are consistently higher than those from the geostationary data and are similar to the overestimates of the NOAA-11 data.

2.2.2 Vegetation Index (Halpert, Schultz, Ropelewski)

A study was initiated to identify temporal correlations between the Vegetation Index (VI), temperature and precipitation. The findings will be used to determine the spatial variability of the relationships and to evaluate the potential for the combined use of the VI and temperature for global bioclimate monitoring. Global monthly data were correlated at each grid point (1^o latitude by 1^o longitude), by using both the anomaly and standard (with annual cycle) time series. The standard correlation between the VI and precipitation is shown in **figure 16**.

The onset of precipitation appears to act as the trigger for vegetation in regions where the amplitude of the annual temperature cycle is small. In regions where the onset of the wet season is sudden, vegetation lags behind precipitation. In cold regions, vegetation is shown to be limited by temperature only, and by both precipitation and temperature in temperate regions. In warm regions, temperature plays a limited role in modulating the seasonal cycle of vegetation, because temperature exceeds the minimum necessary for vegetative growth. Conversely, some extremely wet areas receive rainfall amounts in excess of a minimum threshold above which vegetation is unresponsive.

2.2.3 Satellite Diagnostics Data Base (Basist)

Two archives of satellite data were designed for use as a climate diagnostic tool. These data sets will provide global coverage of various surface and atmospheric parameters and will be archived on an optical disk. All the specifications for data collection, resolution, format design, and archive medium have been defined and are listed below.

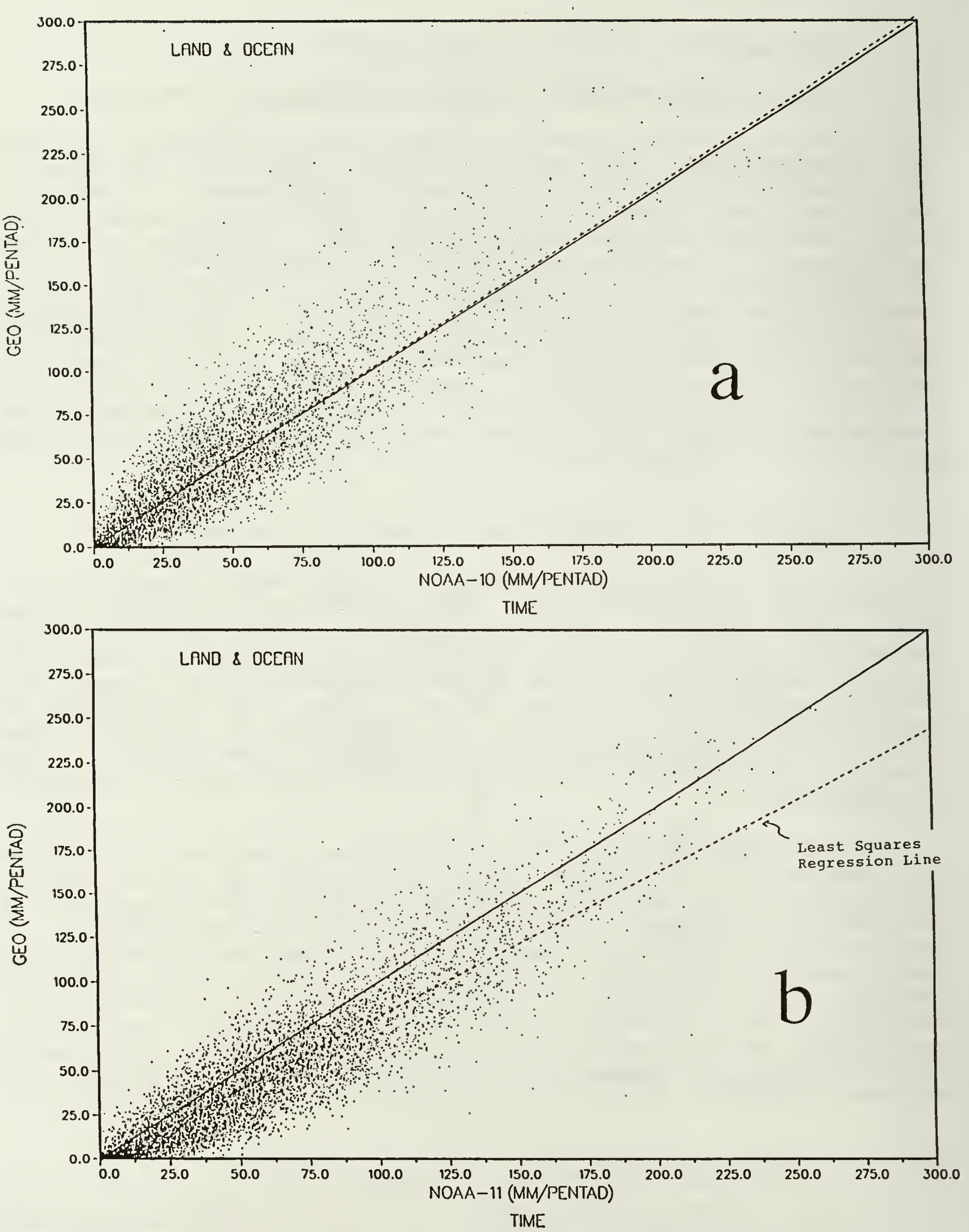

Figure 15: Scatter diagram of time-matched rainfall estimates from geostationary satellite data vs. NOAA-10 (a), and NOAA-11 (b) for the period June 1989 through August 1991. Dashed line is the least squares regression line.

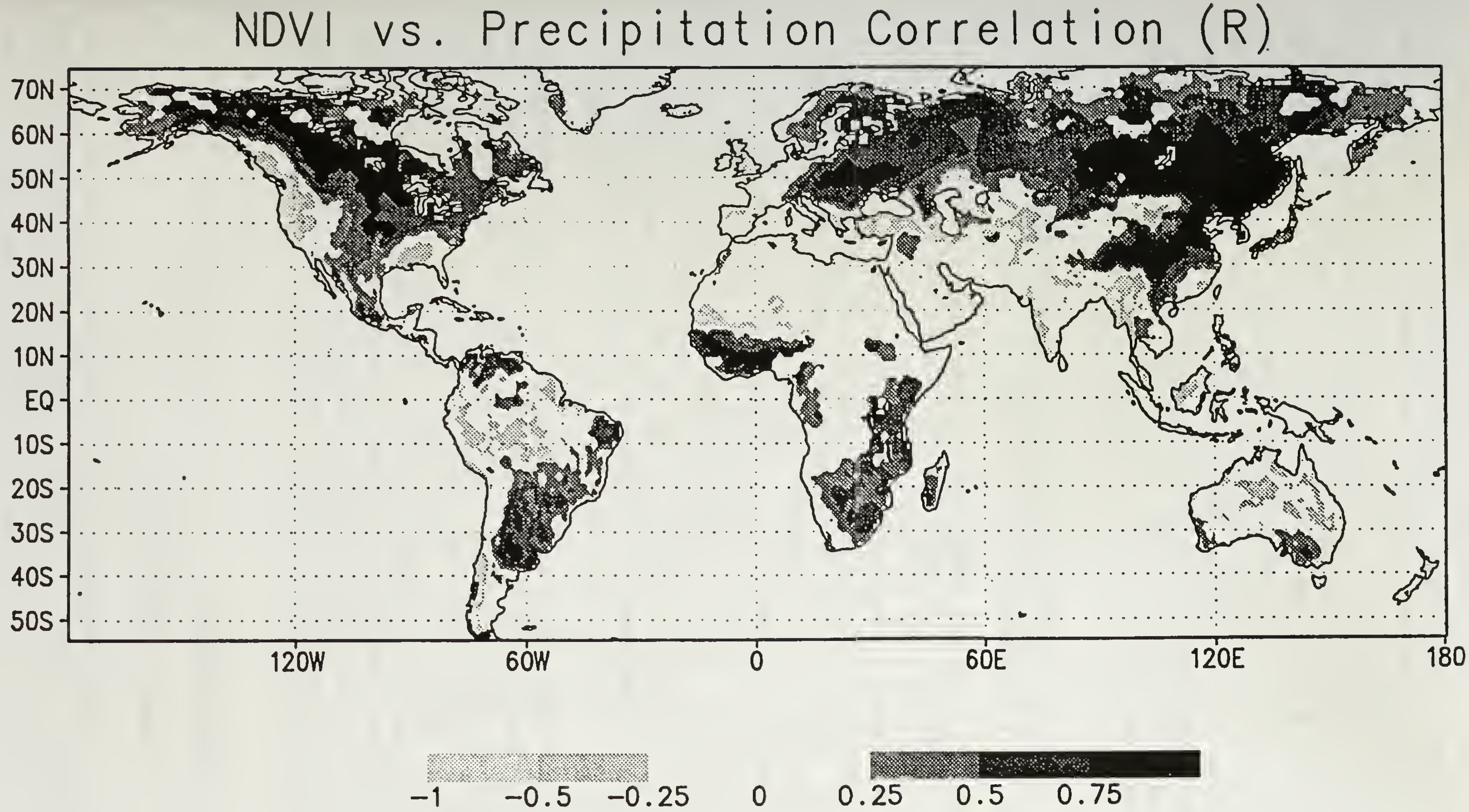

Figure 16: Correlation between the Normalized Difference Vegetation Index (NDVI) and monthly mean precipitation. White areas represent either regions with correlations less than 0.25 in magnitude, flagged regions, or water.

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The first archive will contain data from the 7 channels of the Special Sensor Microwave Imager (SSM/I). From these channels, products will be derived for sea-surface winds, snow cover, sea ice, precipitation, cloud liquid water, total precipitable water, and soil moisture. The spatial resolution of the data set will be 1°, and the temporal resolution will be 5 days. The second archive will contain data from all 4 channels of the Microwave Sounding Unit. Software (developed by R. Spencer, U. of Alabama) will be used that limb corrects, filters for deep convection, removes the diurnal and mean annual cycle, and standardizes all the values to simulate a NOAA-6 satellite pass. The resultant values will be placed into 2.5° latitude-longitude grid-boxes and then averaged over a five-day period.

2.2.4 Comparison of Numerically-Modeled and Satellite-Derived Tropospheric Temperatures (Basist)

Comparisons were made between tropospheric temperatures derived from MSU channel 2 measurements with values from the NMC/Global Data Assimilation System (GDAS) from 1979 to 1990. Both data sets accurately detect large changes, as shown in **figure 17**. The best correlations occur at high-latitude regions, where radiosondes provide ample coverage for the GDAS and where the troposphere exhibits large monthly anomalies. Furthermore, when model biases were removed from the GDAS (in 1989), the correlation between the 2 data sets was higher than 0.97 globally. However, poor correlations with the MSU values were noted in most years over areas of high terrain and tropical land masses, due to temporal changes and to data limitations in the GDAS. Comparisons between the data sets also indicate that frequent model changes can mask the climate signal in the GDAS.

Over land surfaces, where the GDAS is data rich and where the 2 data sets are independent, both data sets display similar patterns of spatial and temporal variability. However, the spatial resolution produced by the GDAS is slightly higher than the one from the MSU (**fig. 18**). Over land surfaces with limited data, the GDAS produces excessive spatial variability relative to the MSU temperature fields (**fig. 19**). Over ocean areas, the two data sets exhibit similar spatial variability (**fig. 20**), which is largely a consequence of satellite data being assimilated into the NMC model over these areas.

2.3 Atmospheric Circulation

2.3.1 Tropospheric Anomalies (Kousky)

A joint study was performed (with K. Mo) to investigate the principal global modes of anomalous upper tropospheric streamfunction. CAC's pentad archive served as the basis for this study, which enhanced the examination of variability on intraseasonal to interannual time scales. Results indicate that

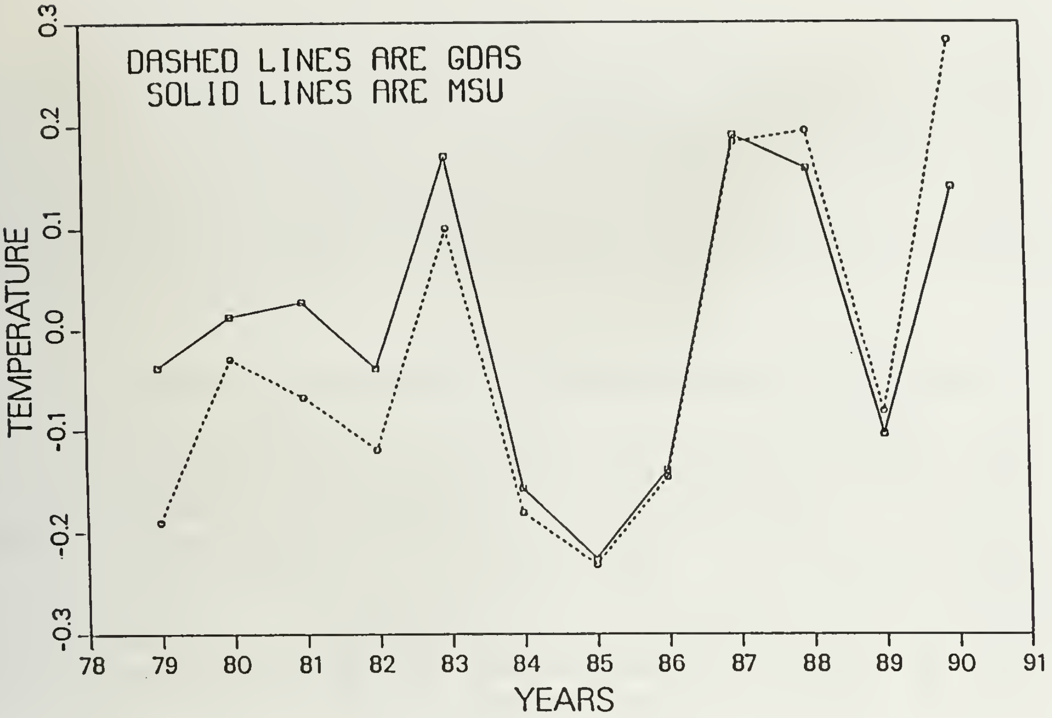


Figure 17: Annual time series of global temperature anomalies for GDAS (dashed) and MSU (solid).

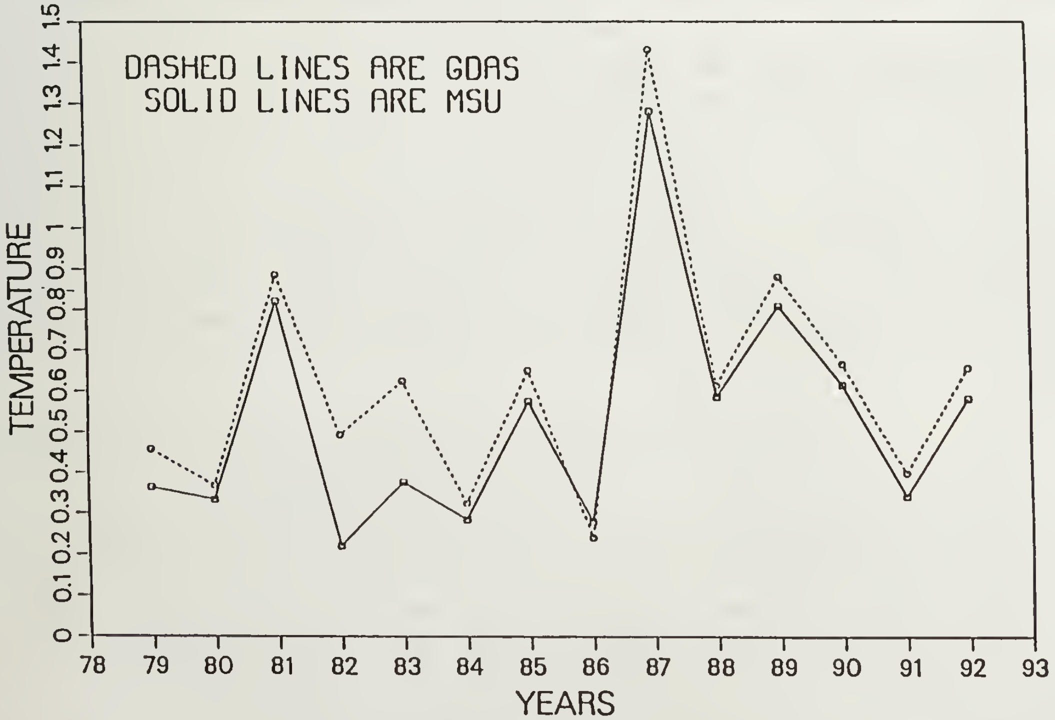


Figure 18: Time series of spatial variability over northeastern Europe for January. This is both an area where the GDAS is rich in data and when there is considerable spatial variability in temperature. Both data sets show similar patterns.

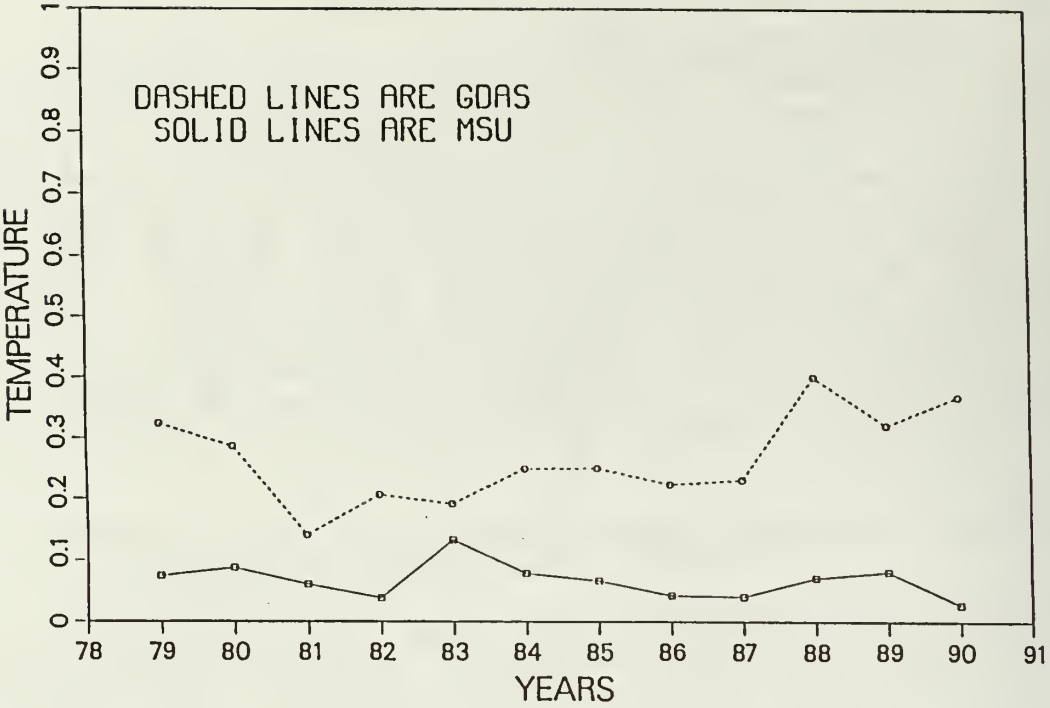


Figure 19: Same as figure 18, except over the Amazon Basin in January. Over this region the GDAS has limited data to assimilate into the model; consequently, it introduces an unreasonable amount of spatial variability over the region.

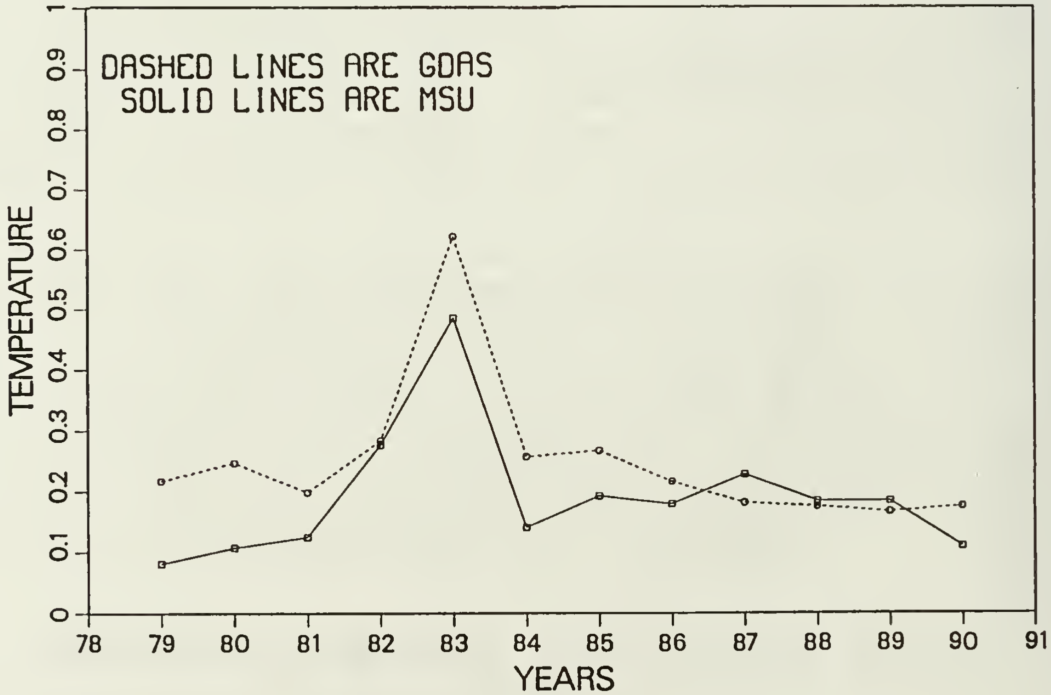


Figure 20: Same as figure 18, except over the tropical Pacific Ocean. The GDAS has limited conventional data; but, data assimilated from the TIROS sounder improves the spatial resolution, relative to the Amazon Basin (where satellite data are not used).

the lowest modes describe spatial and temporal variability associated with extremes in the Southern Oscillation. Low-frequency (interannual) and high-frequency (intraseasonal) variations have similar global-scale anomaly patterns. These patterns appear to be closely related to variations in convective activity within the tropics. A manuscript, describing the results of this study, was written and has been accepted for journal publication.

2.3.2.1 Improved Tropospheric Analyses and Data Bases (Janowiak)

A plan was written which describes the next generation Climate Diagnostics Data Base (CDDB) that will incorporate products from the Reanalysis and CDAS efforts. This "improved CDDB" will contain 28 vertical levels and will reside in both mainframe and workstation environments. The horizontal spectral resolution will be approximately the same one as the current CDDB. When the Reanalysis Project starts, the data will be archived for each data-assimilation cycle (4 times daily). This will enable time-averaging as each user desires.

2.3.2.2 Improved Tropospheric Analyses and Data Bases (Chelliah)

Data base quantities are being archived to quality control monthly mean values (from October 1978 - May 1992). Time series of a global mean and spatial standard deviation, as well as a mean and a spatial standard deviation over the tropics have been computed for 115 fields in the data base. These fields include: wind components, mean virtual temperature, geopotential height, vertical velocity and various covariance terms for nine standard pressure levels. Global time series plots (mean and standard deviation) have also been produced for wind components, mean virtual temperature, and geopotential height. These plots reveal changes associated with various model developments that have taken place over the last 15 years.

2.3.3 Mid-latitude Monitoring Program (Bell)

The development of diagnostic tools, designed to study short-term climate evolution in the extratropics, have focused on two areas. The first one involved diagnostics and indices for use in monitoring mid-latitude climate variability. The second one involved the development and implementation of software that temporally-filters daily grid point data, and the design and implementation of diagnostics based on spatially- and temporally-filtered data. These new diagnostics include: variance analyses of Southern Hemispheric 500 mb heights, time-filtered variance analyses, and recursively-filtered teleconnection indices.

Other diagnostic tools were developed that utilize time-, space-, and time/space-filtering techniques to monitor climate variability in mid-latitudes. These diagnostic tools include: space/time-filtered time series analyses, polar stereographic analyses that show space/time-filtered correlation and covariance analyses, polar stereographic analyses and time-longitude sections. **Figure 21** shows the spatial structure and evolution of space/time-filtered height fields.

2.4 Operational Products

2.4.1 Climate Diagnostics Bulletin (Kousky)

The Climate Diagnostics Bulletin (CDB) focused on the evolution of the 1991-92 Pacific warm episode, which entered into its mature phase during late 1991. By the end of February 1992, the anomalous circulation pattern at upper-tropospheric levels was similar to that observed during the mature phase of previous warm episodes. An upper-level anticyclonic couplet was evident straddling the equator in the central Pacific. Also, an enhanced subtropical jet stream extended from the central North Pacific eastward across Mexico and the Gulf of Mexico. This feature was associated with wetter than normal conditions from northern Mexico eastward throughout most of the Gulf Coast region, which is typical of the northern winter during the mature phase of warm episodes.

The peak of the warm episode occurred during March-May 1992. Between May and July a rapid decrease in sea-surface temperature anomalies was observed throughout the eastern equatorial Pacific as ENSO-like conditions rapidly faded (**fig. 22**); however, positive SST anomalies remained in the central equatorial Pacific through September and low-level equatorial easterlies remained weaker than normal. Throughout this event, CAC issued a series of monthly ENSO Advisories until July 1992. These Advisories included: descriptions of the anomaly patterns in the tropical Pacific, their evolution, and the probable impacts that the warm episode would have on global temperature and precipitation patterns. In recognition for this authoritative information and guidance, members of CAC's ENSO monitoring and prediction team were awarded the Department of Commerce Silver Medal.

The Climate Diagnostics Bulletin also contained updates concerning the stratospheric aerosols caused by the June 1991 eruption of Mt. Pinatubo in the Philippines, and also included similar information for the August 1991 eruption of Mt. Hudson in South America. In addition, the CDB was revised by adding a Table of Contents, by separating the Tropics, Forecast Forum and Extratropics Sections, and by deleting redundant figures.

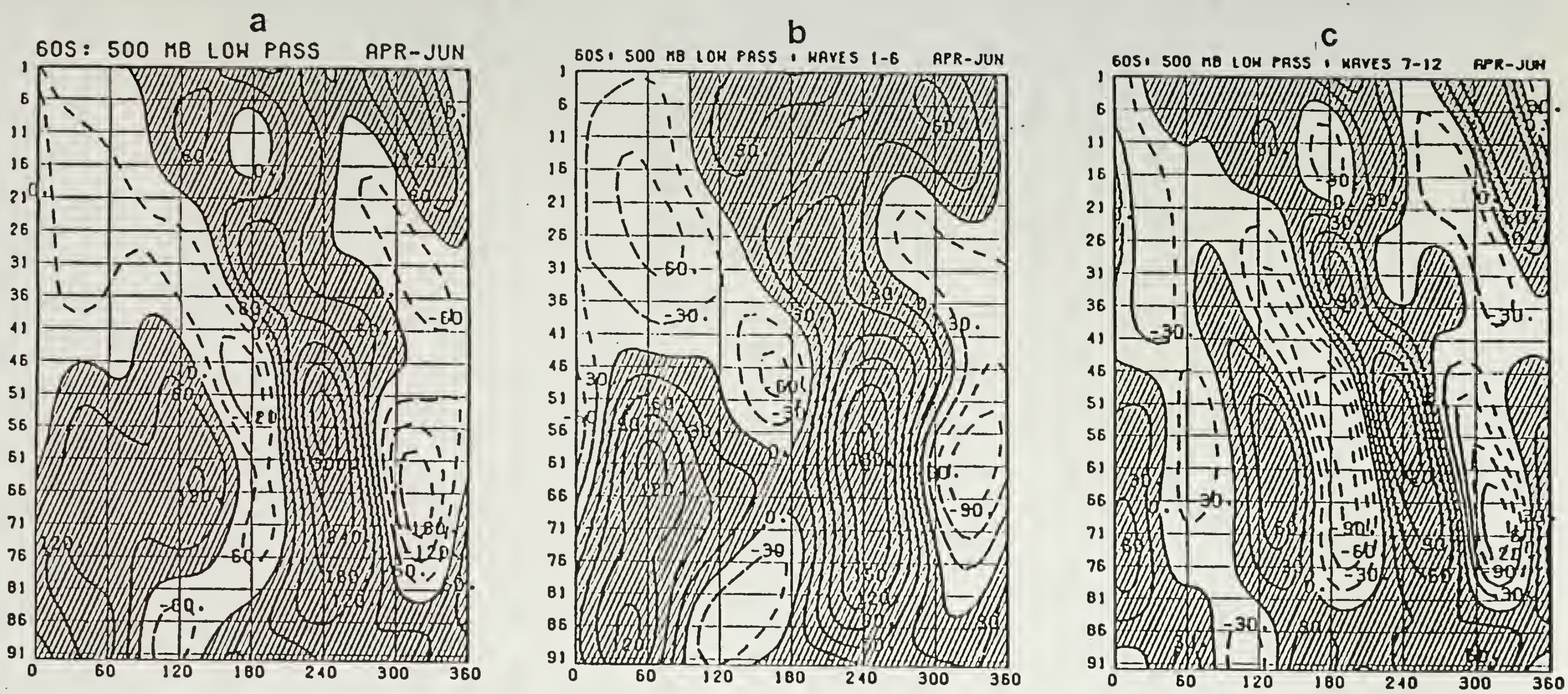


Figure 21: Southern Hemisphere: Daily low-pass filtered (30-day low pass) 500 mb height anomalies for April-June 1991 averaged over the 10^o latitude band centered on 60^oS. Panel (a) shows the full filtered height field (interval is 60 m); Panel (b) shows the planetary scale (two-dimensional wavenumbers 0-6; interval is 30 m) height anomalies; Panel (c) shows the sub-planetary scale (two-dimensional wavenumbers 7-12; interval is 30 m) height anomalies. Anomalies are computed with respect to the 1979-1988 base period. Specified wave groups are identical to those described by Blackmon (J. Atmos. Sci., 1976,1607-1623). Positive height anomalies are shaded in all panels.

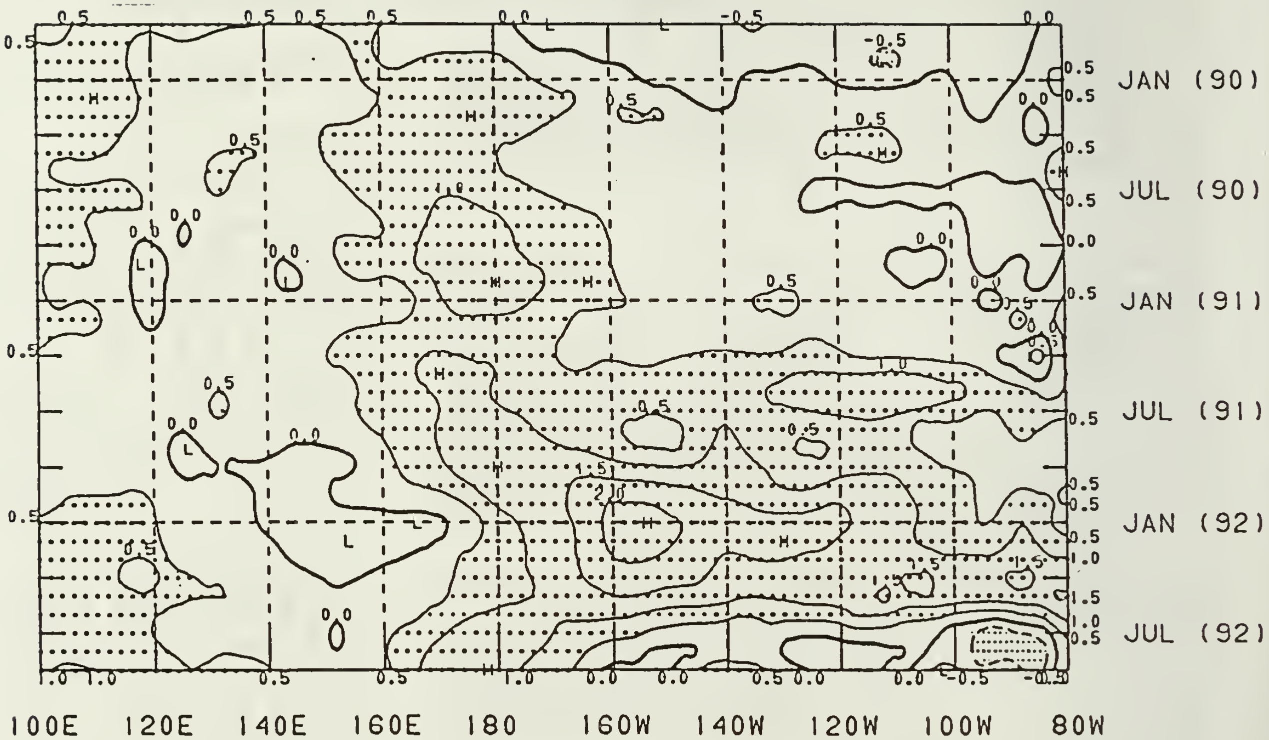


Figure 22: Time-longitude section of monthly sea surface temperature anomalies. Contour interval is 0.5°C. Anomalies less (greater) than -0.5 (0.5) are shaded (stippled).

2.4.2 Seasonal Climate Review

2.4.2.1 September - November 1991 (Janowiak)

After six to twelve months of "warm episode-like" conditions in the tropical Pacific, it is now apparent that an El Niño/Southern Oscillation (ENSO) event has begun. The lack of enhanced convection in the equatorial central Pacific until this season precluded the pronouncement of a full-fledged ENSO event. But a dramatic increase in convection along the equator near the date line in conjunction with collapsing equatorial easterlies east of the date line, consistently negative Southern Oscillation Index (SOI) values, persistent positive sea-surface temperature (SST) anomalies in much of the central Pacific, and a large reservoir of warm sub-surface water all indicate that an ENSO event has begun. In particular, the increased convection in the region of positive SST anomalies provides solid evidence that an atmospheric-oceanic coupling has evolved, which is a critical element in ENSO development and sustenance.

In the mid-latitudes, the most pronounced feature was the preponderance of above-normal surface temperature throughout much of the Northern Hemisphere. Below normal temperatures were confined primarily to central and western North America. Large regions of warmer than normal mean surface temperature, particularly in central and northern Asia and Southeast Asia, were apparent. In the Southern Hemisphere, above-normal surface temperatures were observed over much of Australia.

2.4.2.2 December 1991 - February 1992 (Kousky)

A major highlight of this season was a strengthening of the tropical Pacific warm episode. Sea -surface temperature (SST) anomalies increased in the eastern equatorial Pacific, as El Niño conditions developed along the west coast of South America. Enhanced tropical convection persisted in the central Pacific near 160°W, which was in the vicinity of the largest SST anomalies (more than +2°C). Many regions world-wide experienced temperature and precipitation anomalies consistent with those found during the mature phase of warm episodes. In North America, wetter than normal conditions were observed over northern Mexico and many parts of the U.S. Gulf Coast. Meanwhile, above-normal temperatures were observed in western Canada and in the Northern and Central Plains of the United States. Other features, which are consistent with a mature warm episode, include: drier than normal conditions over most of Indonesia, the Philippines, northern Australia, and southeastern Africa.

Perhaps the largest and most persistent anomalous circulation feature in the Northern Hemisphere was not directly attributable to the tropical Pacific warm episode. A strong upper-tropospheric ridge dominated northern Europe through nearly the entire season. This feature was associated with warmer than normal conditions over northern Europe and much colder than normal weather over sections of the Middle East. A number of unusual heavy snowfalls fell in the latter region, while most of Europe was drier than normal.

2.4.2.3 March - May 1992 (Wang)

During this season, the El Niño/Southern Oscillation (ENSO) warm event in the tropical Pacific went from a mature phase to a decaying stage. The global-scale atmospheric circulation showed typical mature phase patterns in March and April and started to decay in May. Sea-surface temperature anomalies decreased over the central Pacific, while increasing along the west coast of South America. However, enhanced tropical convection still persisted in the central Pacific near 160°W. Many regions experienced temperature and precipitation anomalies consistent with those found during the mature phase of a warm event. Heavy rainfall over the southwestern United States and northern Mexico was directly related to an enhanced subtropical jet stream, which resulted from the strong convective activity in the equatorial central and eastern Pacific. Drought conditions were observed in the Philippines, northern Australia, southeast Asia, and southeastern Africa.

The largest and most persistent anomalous circulation feature was an anticyclone over the north Pacific, an apparent consequence of the ENSO. This ridge was responsible for the very high temperature anomaly over the western United States and the cold weather over the eastern Unites States. Over the north Atlantic and northwest Europe, an anomalous tropospheric anticyclone that was less attributable to the warm event was associated with above-normal surface temperatures. In the Southern Hemisphere, the largest circulation anomaly was a 500-mb ridge over the southeastern Pacific.

2.4.2.4 June - August 1992 (Mo)

Warm episode conditions in the tropical Pacific, which started in September 1991 and reached mature phase in December 1991-February 1992, have decayed during the season. Sea-surface temperature anomalies (SSTA) in the central and eastern equatorial Pacific decreased rapidly through the season and, in August, SSTA less than -1°C were found in the eastern Pacific. The depth of the oceanic thermocline, as indicated by the 20°C isotherm in the eastern Pacific (120°W- 80°W), continued to rise since April. The depth of the thermocline rose from 100m to 60m by the end of June and then went up to 20m in August. The outgoing long wave radiation (OLR), SOI, and equatorial winds all indicated a return to the normal pattern of both oceanic circulation and atmospheric convection in the tropics.

In the Northern Hemisphere, below-normal temperatures occurred over much of the land masses in midlatitudes, while above-normal temperatures existed in the subtropics. The United States experienced its second coldest summer since 1951. The Indian monsoon season started later than usual (mid-June); but, rainfall amounts overall were near normal. In the meantime, the drought in Africa continued.

2.4.3 Climate Assessment (Halpert)

A comprehensive review of surface parameters and atmospheric circulation was produced for 1991 that contains descriptive figures on the extent of the global warmth during 1991 and how it compared to the previous year and decade. The global climate of 1991 was influenced by a number of complex and competing influences. The detection of global warming was made more complicated by the short-term competing influences of a moderate El Niño/Southern Oscillation warm episode and a major volcanic eruption (Mount Pinatubo). Nonetheless, the globally-averaged surface temperature for 1991 was the 2nd warmest on record (slightly below 1990) since 1951.

Temperature patterns over the globe had many characteristics reminiscent of the entire decade of the 1980's. As in the past decade, the largest positive temperature anomalies were found over central and eastern Eurasia, and northwestern North America. Negative temperature anomalies were found over northeastern Canada and western Greenland. The main difference from the persistent temperature pattern of the 1980's over land was that the area of largest positive temperature anomalies extended further eastward across the United States (**fig. 23**).

2.5 Supporting Projects

2.5.1 Workstation Graphics/Software (Garrett)

CAC's Diagnostics Branch has acquired additional hardware and software to facilitate data management and climate diagnostic studies. These acquisitions include: SGI and SUN workstations, a PC486, and two PC386's. One of the PC386's was upgraded to enable X-Window software to be used efficiently. The X-Window software enables PC users to perform functions remotely on workstations. A number of peripherals were also obtained for easier access to workstations.

A number of upgrades were made on the SUN Workstations. First, the latest operating system, the EMPRESS Data Base Management System (DBMS), and SAS software was installed on the SUN16. Also, a SPARC laser printer was acquired that is identical to the one attached to SUN17. In addition, the memory of the SUN17 has been increased from 16Mb to 28Mb to accommodate the large amount of memory used by the SPARC laser printer.

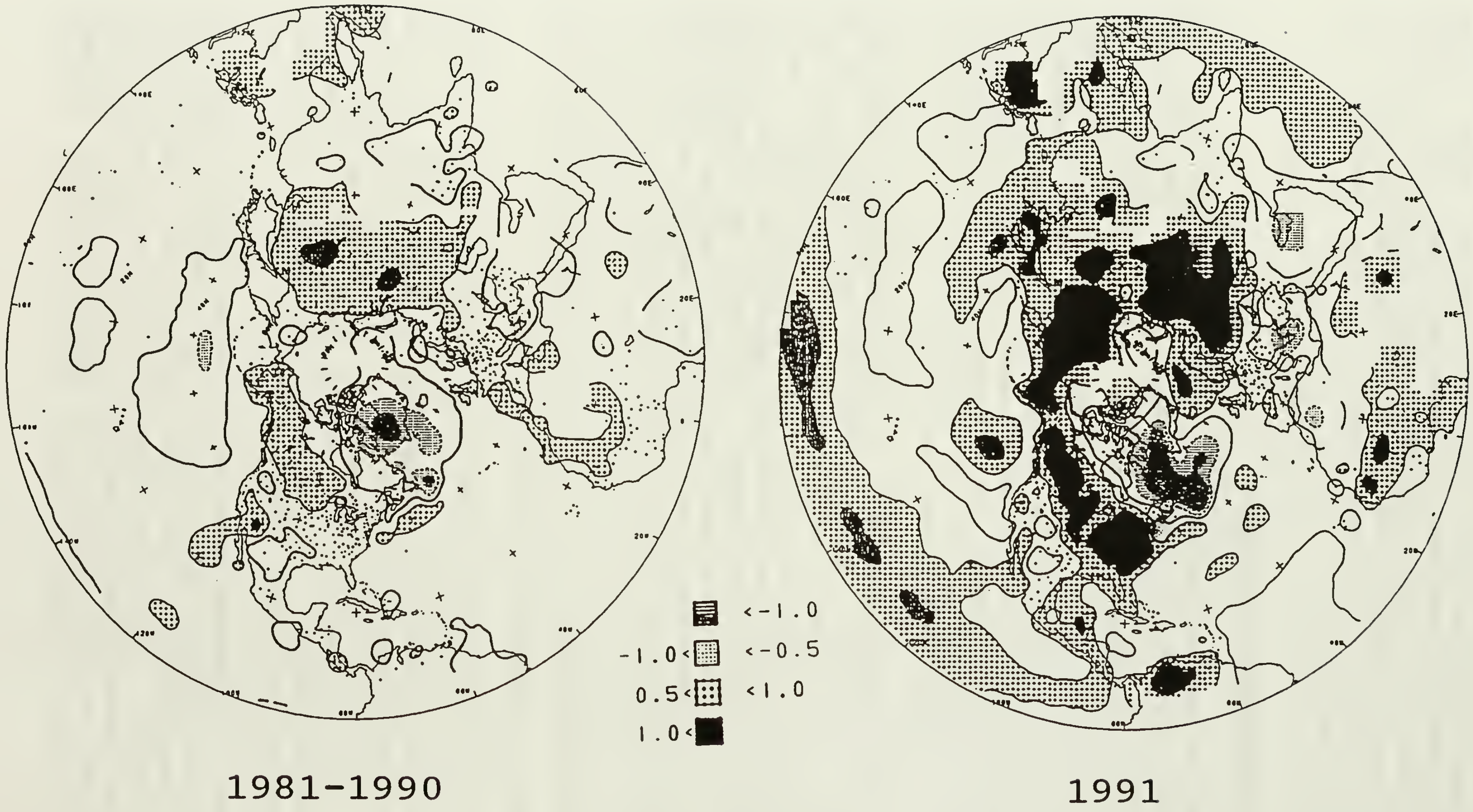


Figure 23: Northern Hemisphere surface temperature anomaly for the 1981-1990 period (left) and for the year 1991 (right). Anomalies for station data (land) are from the 1951-1980 base period; SST anomalies are computed from COADS/ICE climatology. Data locations on land are indicated by plus sign; contour interval is 0.5°C, with negative anomalies dashed.

3. SURFACE CLIMATE MONITORING

3.1 Operational Products

3.1.1 Surface Temperature and Precipitation (Tinker)

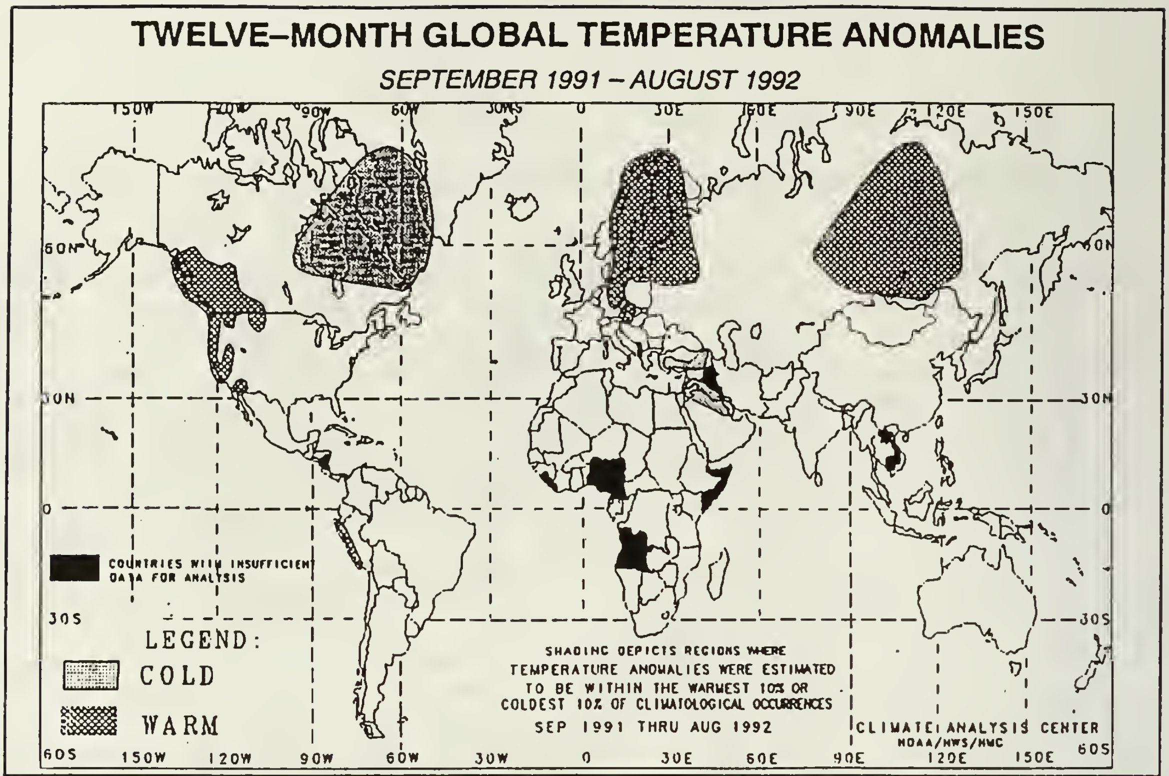
Several areas of the globe experienced abnormally low temperatures during 1992, in sharp contrast to the widespread, persistent warmth observed throughout much of the world in the 1980's and early 1990's. The oceanic and atmospheric anomaly patterns of the moderate warm ENSO episode that commenced in 1991 rapidly faded as conditions returned to near normal by mid-1992. During the 1991-92 ENSO event, climate anomalies observed in many regions (**fig. 24**) were consistent with those generally found during warm episodes.

Hurricane Andrew, the most destructive natural disaster ever to strike the U.S., raced through the northern Bahamas and southern Florida in late August with sustained winds of up to 225 kph. Andrew inflicted an estimated $30 billion in damages in Florida alone and caused an estimated 60 deaths in the Bahamas, Florida and Louisiana. The 1992 Atlantic hurricane season, however, was below normal for the second consecutive year with only six named storms. Hurricane Iniki became the strongest Pacific hurricane to affect Hawaii in 90 years, as sustained winds reached 225 kph just before it struck Kauai in September. Preliminary damage estimates were $1.5 billion.

Numerous storms and ample moisture spread across the southern tier of the U. S. during the first half of 1992, with parts of Texas receiving up to 1040mm of rain. The 1991-1992 wet season in the western U.S. brought enough precipitation across some southern sections to nearly alleviate the effects of the six-year drought. Farther north, however, the drought continued as subnormal winter precipitation occurred. This dryness combined with unusually high temperatures abetted several outbreaks of wildfires during the summer and fall. Over a million acres of Western forests and grasslands were charred.

In the United States, temperatures during June through August 1992 averaged much below normal east of the Rockies, ranking 1992 as the third coolest summer nationally. It was also the third wettest summer across the contiguous 48 states since 1895. In addition, a record high number of tornadoes was reported during June and July.

In Africa's western Sahel, the 1992 rainy season started slowly; but, heavy rains in July and August brought seasonal totals to near average except for parts of Senegal, Mauritania, Ethiopia and Somalia. An extreme drought, reportedly the worst in 100 years, afflicted much of southern Africa during the 1991-1992 rainy season, greatly reducing agricultural production.

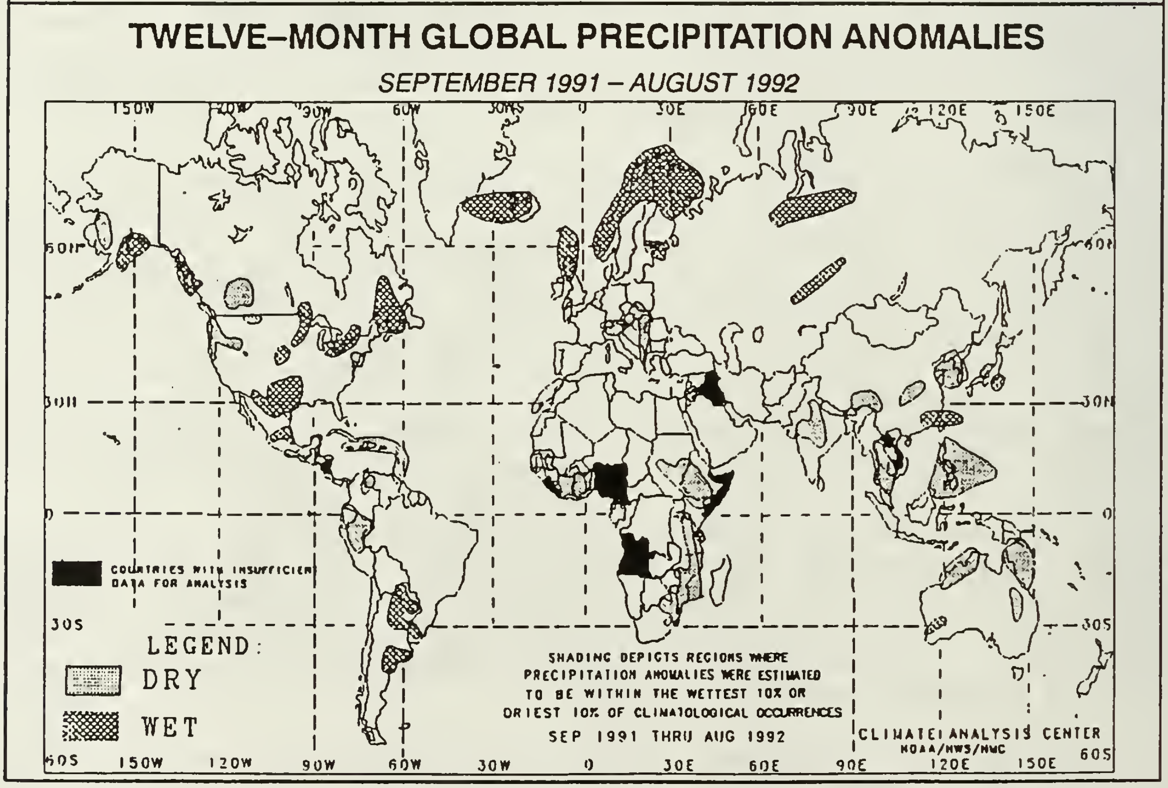


TWELVE–MONTH GLOBAL TEMPERATURE ANOMALIES

SEPTEMBER 1991 – AUGUST 1992

SHADING DEPICTS REGIONS WHERE TEMPERATURE ANOMALIES WERE ESTIMATED TO BE WITHIN THE WARMEST 10% OR COLDEST 10% OF CLIMATOLOGICAL OCCURRENCES SEP 1991 THRU AUG 1992

CLIMATE ANALYSIS CENTER NOAA/NWS/NMC



TWELVE–MONTH GLOBAL PRECIPITATION ANOMALIES

SEPTEMBER 1991 – AUGUST 1992

SHADING DEPICTS REGIONS WHERE PRECIPITATION ANOMALIES WERE ESTIMATED TO BE WITHIN THE WETTEST 10% OR DRIEST 10% OF CLIMATOLOGICAL OCCURRENCES SEP 1991 THRU AUG 1992

CLIMATE ANALYSIS CENTER NOAA/NWS/NMC

Figure 24: Significant global temperature and precipitation anomalies for September 1991 - August 1992. Shading depicts regions where anomalies were estimated to be within the warmest/wettest (double hatched) or coldest/driest (dotted) 10% of 1951-1980 climatological occurrences.

Much of Europe experienced unusually dry conditions during the summer. A mid-August heat wave supported large wildfires in Poland, the southern Baltic countries, and western Russia. Late summer rains finally ended the dry spell in northern Europe, but a series of September and October storms dumped heavy rains on portions of Spain, France, and Italy.

The Asian monsoon, after a slow start, brought widespread and abundant rains to northern, western, and central India and most of Pakistan in July. The seasonal rainfall totals were near normal. Early September rains in northern Pakistan and India melted the mountain snow pack that caused landslides and catastrophic flooding. An estimated 4,000 lives were lost, millions of people were displaced, and agricultural and property losses were huge in the worst floods since 1947.

In other parts of Asia, heavy spring rains also produced mud slides that claimed hundreds of lives in Tajikistan. During March, excessive precipitation over much of eastern China, Taiwan, the Ryukyus, South Korea, and western Japan caused a variety of impacts. From late June into mid-July, heavy rains fell on parts of southeastern China, causing the worst flooding in Fujian province in 50 years. This wet spell ended abruptly in interior southeastern China in late July, as only 25-50% of normal rain fell from mid-summer through October causing crop damages. From late 1991 into mid-1992, persistently low rainfall in the Philippines caused 300mm deficits in northern sections to 1000-2000mm deficits in typically wetter southern locations. From mid-July through early September, inundating rains produced deadly flows of combined volcanic ash and mud near Mt. Pinatubo.

The rainy season in northern Australia, typically November-March, was slow to start until heavy mid-January rains fell on the east-central and northeastern sections of the country. In late February, cyclones Daman and 18P dumped excessive rains on parts of southeastern Queensland. The rain benefited many previously-stressed crops in central and northern Queensland, but in southeastern Queensland, the copious rains generated some of the region’s worst flooding this century.

In central portions of South America, January rainfall produced severe flooding in portions of northern Argentina, and torrential downpours caused flash flooding and mud slides in the suburbs of Rio de Janeiro. Very wet weather persisted across many portions of the area as the summer progressed. Then, in May when totals normally decline, rainfall dramatically increased as amounts exceeding 400 mm drenched the Brazilian states of Rio Grande do Sul and Catarina causing chronic floods. Unusual warmth dominated large areas of South America during March-June, with the largest departures (+4°C) along the equatorial Pacific Coast due to the effects of the ENSO event. Cool air covered most of the continent during June-September as temperatures averaged as much as 4°C below normal in Bolivia.

3.1.2 Climate Assessment Data Base (CADB) (Miskus, Fulwood)

Daily, weekly, and monthly CADB production runs continued without any major delays or problems. Also, modifications and format improvements were made to the archived daily and monthly CADB data on an optical disk to accelerate the downloading of data. The new format required 10% more disk space, but greatly decreased extraction time. All CADB data (since 1987) have now been reformatted on to optical disk and transmitted electronically to the National Climatic Data Center (NCDC). In addition, plans were formulated to transfer the CADB on to a VAX computer to increase space and turn-around time. After acquiring 2 gigabytes of storage on the VAX4000, work focused on determining a data base management system, the amount and length of data records in the new CADB, and software requirements.

New 30-year monthly and daily U.S. normals for 1961-1990 were received from NCDC for implementation in January 1993. These normals, along with 1961-1990 CAMS monthly normals for remaining global locations, are currently being tested for incorporation into the CADB.

A joint effort between the CAC, NCDC, Texas A&M, and NCAR is nearly completed in the production of CD-ROMs that contain daily global weather data (since 1977). Daily CADB data since 1987 were sent to Texas A&M to be merged with historical CADB data from 1977-1986. These data were then forwarded to the NCDC for CD-ROM storage and will be submitted to the USDA as a finished product after evaluation.

A 5-year plan (Meteorological Environmental Data System Initiative) was prepared that lists the computer hardware and data base requirements for FY93-FY97. This Initiative includes: the requirements for the CADB, Climate Dial-Up System, Joint Agricultural Weather Facility, and Regional Climate Centers.

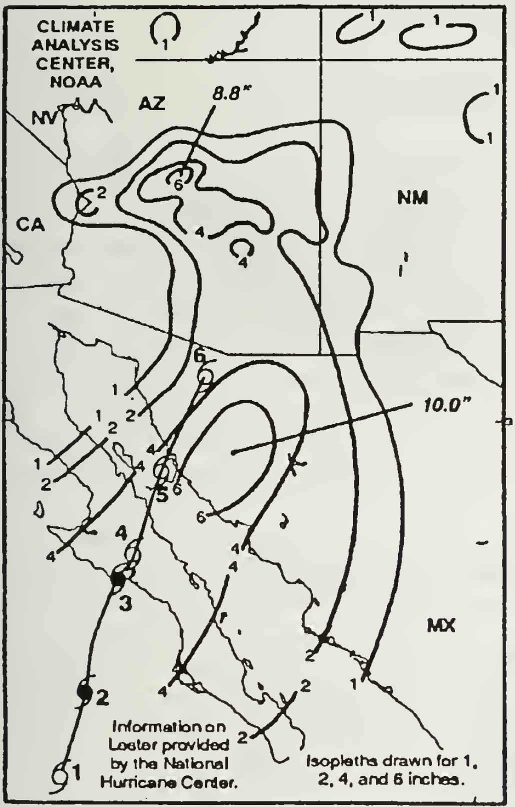
3.1.3 Weekly Climate Bulletin (Tinker, Sabol)

The format of the Weekly Climate Bulletin (WCB) changed dramatically, as emphasis was placed on publishing more striking graphics. Based on user response, maps now contain less routine graphics and more space is devoted to highlighting events as conditions warrant. In addition, the WCB was downsized and reformatted to reduce reproduction cost. After published products were either reduced in size or eliminated, a second highlights page was introduced (**fig. 25**).

Other changes included: placing U.S. analyses and global percentile analyses onto a single page, reducing the Monthly and Seasonal U.S. Climate Summaries in size, generating fewer special summaries, and putting anomalies on the highlight page.

NORTH AMERICAN HIGHLIGHTS FEATURES

TOTAL PRECIPITATION (IN)
and
PATH OF HURRICANE LESTER
AUGUST 19 – 24, 1992



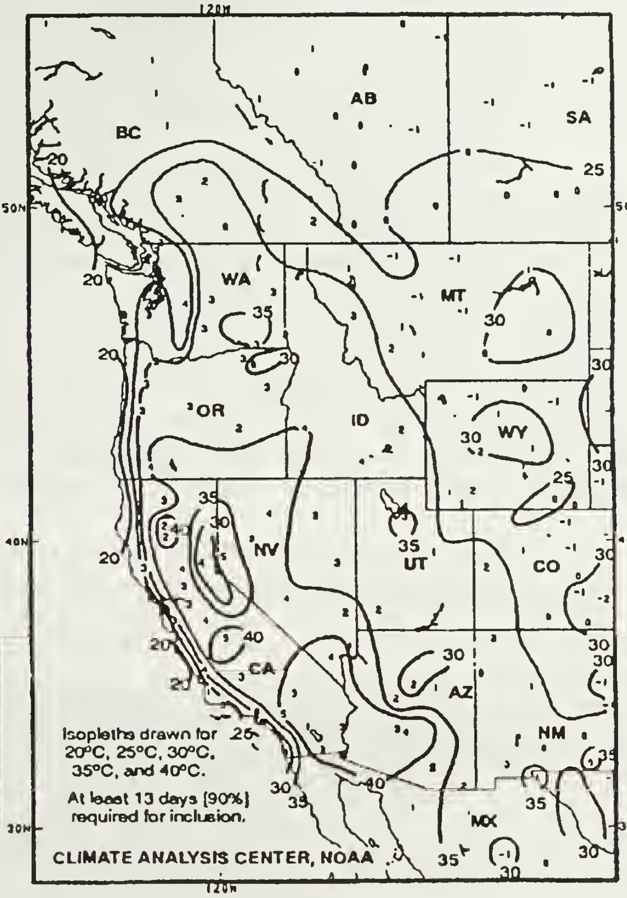
Information on Lester provided by the National Hurricane Center.

Isopleths drawn for 1, 2, 4, and 6 inches.

1 *Tropical Storm Lester 2 AM PDT 8/22*
Maximum winds 60 mph
2 *Lester becomes a hurricane 8 AM PDT 8/22*
Maximum winds 75 mph
3 *Lester makes landfall 2 AM PDT 8/23*
Maximum winds 75 mph
4 *Lester drops below hurricane strength 8 AM PDT 8/23*
Maximum winds 70 mph
5 *Lester over Baja Gulf 2 PM PDT 8/23*
Maximum winds 60 mph
6 *Tropical Storm Lester dissipates 8 PM PDT 8/23*
Mx. winds 35 mph (remnants continued northeastward)

MOISTURE FROM LESTER DRENCHES NORTHWEST MEXICO AND THE SOUTHWESTERN U.S. *Tropical moisture from Lester begun spreading into northwest Mexico and the desert Southwest late last week, generating locally heavy thunderstorms and isolated flash floods throughout the region. Early Sunday morning, Hurricane Lester swept into central Baja California and continued northeastward to near the Arizona border before disintegrating as an identifiable tropical system; however, Lester's remnants continued northward, bringing wind gusts reaching 40 mph to the Phoenix, AZ area and dumping more heavy rain on parts of the Southwest. Up to 10 inches of rain drenched northwestern Mexico and as much as 8.8 inches soaked central Arizona in association with Lester and/or it's remnants.*

PLOTTED VALUES: DEPARTURE OF AVERAGE TEMPERATURE FROM NORMAL (°C)
CONTOURS: AVERAGE MAXIMUM TEMPERATURE (°C)
AUGUST 9 – 22, 1992



Isopleths drawn for 20°C, 25°C, 30°C, 35°C, and 40°C.
At least 13 days (90%) required for inclusion.

CLIMATE ANALYSIS CENTER, NOAA

TWO WEEKS OF HOT WEATHER HELP FUEL NUMEROUS LARGE WILDFIRES. *Temperatures averaged up to 6°C above normal in parts of the Far West during the last two weeks. The average daily maximum exceeded 40°C as far north as the valleys of northern California, with highs averaging over 30°C northward into southern British Columbia. According to press reports, the heat helped to fuel a slew of wildfires across the Far West. As of Friday, August 22, dozens of wildfires had charred more than 200,000 acres across six western states. Over 120,000 acres were scorched in Idaho alone. In sharp contrast, the week ended on a wintry note across western Montana. Readings dropped below freezing only days after highs had soared above 35°C. The season's first snowfall accompanied the invasion of cold Canadian air, and some of the higher elevations had received several inches of snow by Sunday.*

Figure 25: Example of the new North American Highlights Feature in the Weekly Climate Bulletin (WCB). Special episodic weather events or short-term climate anomolies in the United States, Canada, or Mexico, such as heavy rains in the Southwest associated with the remnants of Hurricane Lester (left) and a heat wave that exacerbated wildfires in the Far West (right) are now included in the WCB.

Updates continued on the rainy seasons in India, the African Sahel, South America, South Africa and Australia. Input was received from the Regional Climate Centers which was vital for describing the drought in the Far West, early growing season dryness across parts of Illinois and Iowa, and the devastating effects of Hurricane Andrew in Florida and Louisiana.

3.1.4 Climate Information Delivery Service (Fulwood, Dionne)

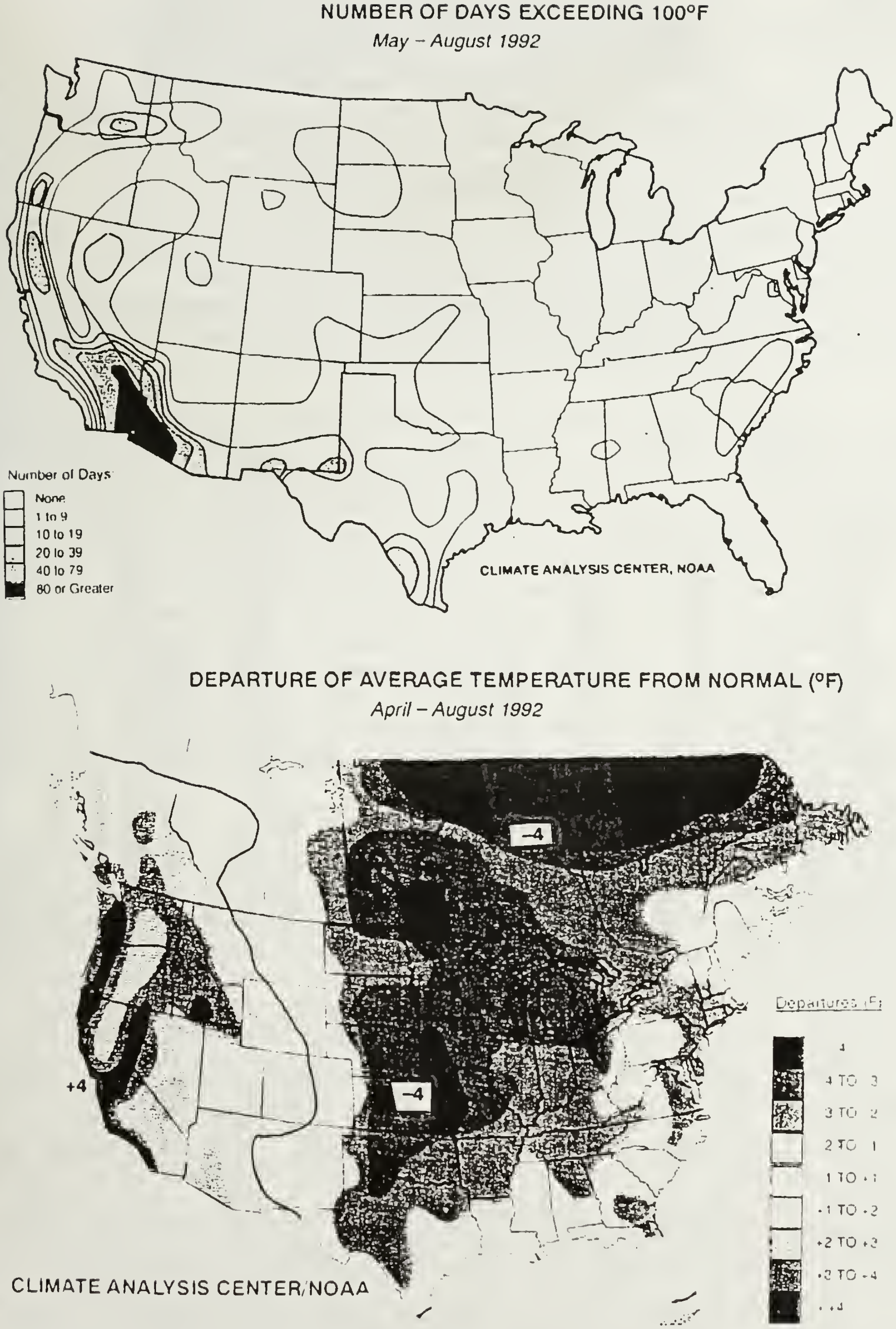
The Climate Information Delivery System (CIDS) is the new name for the collective methods by which CAC electronically transmits climate data and products to users, particularly those not on the National Weather Service's AFOS system. The methods include the NWS/Family of Services - Climate Dial-Up Service (CDUS) and network exchanges. A VAX computer maintains the security of NOAA's central computers, while permitting access to climate information. The network capabilities of the CIDS are being utilized by routine transmission of daily and weekly data to the Regional Climate Centers, and by transmission of daily, weekly, and monthly data to the National Climatic Data Center.

The updating and dissemination of products continued with only minor problems. An investigation revealed that solar radiation files on the CDUS were less complete than the actual data transmission of reporting locations; therefore, the procedure was modified to include both an initial and secondary submission to increase data retrieval. CIDS products are going to be included in a climate data base directory that is being compiled by the National Space Science Data Center.

3.1.5 Special Climate Advisories (Miskus)

A North American Climate Advisory was produced that highlighted short-term dryness in the U.S. corn belt, and Canadian Prairie Provinces in early 1992, along with long-term drought in the far west and unusually cool weather in the eastern half of the U.S. This Advisory, which featured special color graphics, summarized anomalous climate and weather events, their impacts, associated products and data, and outlooks across North America during the 1992 growing season. It was disseminated (in August) to federal, regional, state, and foreign officials, the media, and many scientific organizations. More than 20 organizations and agencies from Canada and the U.S. contributed input.

An updated Advisory was also produced (in September) which highlighted the active wildfire season in the western U.S. and the cool weather in southern Canada and the central United States (**fig. 26**). It is planned to produce at least one North American Climate Advisory each year during the most appropriate phase of the growing season. This will depend on conditions before, during and near the end of the growing season. If conditions warrant, additional advisories may be issued.



NUMBER OF DAYS EXCEEDING 100°F

May – August 1992

DEPARTURE OF AVERAGE TEMPERATURE FROM NORMAL (°F)

April – August 1992

Figure 26: Figure (normally in color) of the North American Climate Advisory #92/2 depicting the cool Summer in the East and the unseasonable warmth in the West. The Advisories, issued as conditions warranted, were a summary of the current conditions, impacts, and outlooks issued by the NMC's Climate Analysis Center with input from numerous Federal, Regional, State, and Canadian agencies.

3.1.6 PRESTO - National Capital Summary (Harrison)

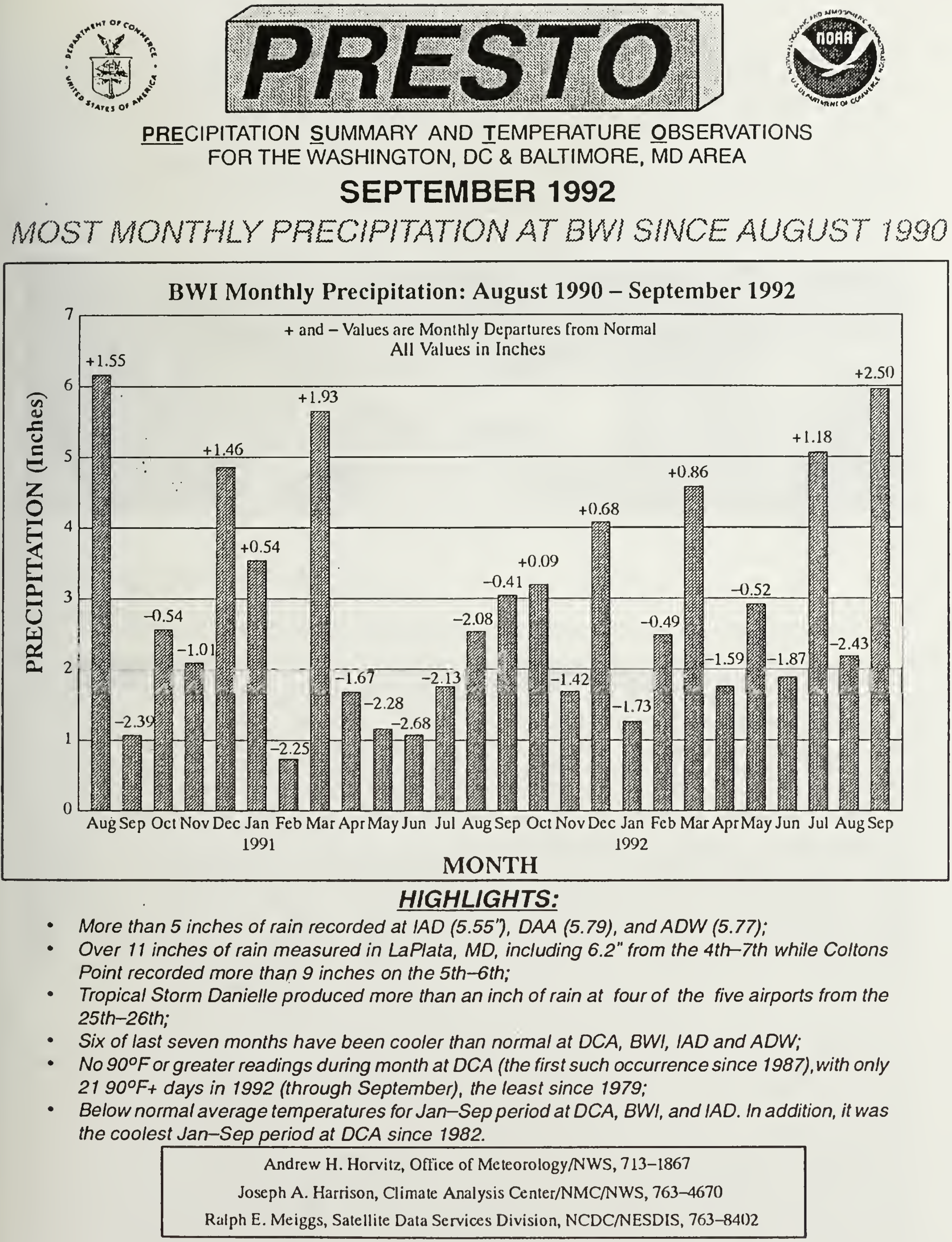
The production of PRESTO was enhanced by software that improved the overall quality and the production time. The first software-derived color graphic was produced in March 1992 and other software was implemented in September that incorporated graphics directly into the text (**fig. 27**). In June, a six-month pilot project began with 12 local area schools to query the educational sector as to the feasibility of employing PRESTO in weather-related science projects at each school. At the end of the period, a written response from the test schools will be evaluated. The number of PRESTO recipients increased by more than 20% in the past year.

A number of notable weather events occurred from October 1991-September 1992 in Washington D.C. Temperatures during the last 3 months of 1991 were above normal at National Airport (DCA), making 1991 the warmest year on record with an average temperature of 60.2°F. No snow was measured during December 1991, the first such occurrence at DCA since 1972. In addition, the winter of 1991-1992 was above normal with only one calendar day (midnight-midnight) with sub-freezing readings. The year 1992, however, is a different story. Either normal or below normal monthly-averaged temperatures have prevailed, so far. Statistics for National include: the coolest May in 25 years, the coolest Spring since 1984, the coolest June since 1974, the coolest August since 1946, and the coolest summer in 20 years.

3.1.7 AID/FEWS (Miskus, LeComte)

CAC provided maps (10-day and monthly) showing satellite-derived and ground-based rainfall and percent of normal rainfall to the Agency for International Development in support of the Famine Early Warning System (FEWS). Weather summaries and Intertropical Convergence Zone data were also provided to FEWS. An archive was generated (on a workstation) that contains 1/2 by 1/2 degree latitude and longitude grids of satellite-derived rainfall estimates for ten-day and monthly periods from April-September. Zone means, biases, and corrections were tabulated for each 10-day period for later study. In addition, a 1/2 by 1/2 degree grid of interpolated monthly normals was created from hundreds of African monthly station normals (courtesy of S. Nicholson, Florida State University). These monthly normals are useful for verification of the rain zones in the Sahel region.

Several new satellite-derived products are now operational for monitoring African rainfall. Color contoured maps with thresholds of 215°K and 270°K are supplementing the current ten-day cold (235°K) cloud-top frequency accumulation map. These color charts (**fig. 28**) are generated on a workstation and are used to determine the frequency of very cold (high) clouds and very warm (low) clouds, respectively. During each ten-day period, ground stations within the area 0-20°N and



PRESTO

PRECIPITATION SUMMARY AND TEMPERATURE OBSERVATIONS
FOR THE WASHINGTON, DC & BALTIMORE, MD AREA

SEPTEMBER 1992

MOST MONTHLY PRECIPITATION AT BWI SINCE AUGUST 1990

BWI Monthly Precipitation: August 1990 – September 1992
+ and – Values are Monthly Departures from Normal
All Values in Inches
PRECIPITATION (Inches)
0
1
2
3
4
5
6
7
+1.55
–2.39
–0.54
–1.01
+1.46
+0.54
–2.25
+1.93
–1.67
–2.28
–2.68
–2.13
–2.08
–0.41
+0.09
–1.42
+0.68
–1.73
–0.49
+0.86
–1.59
–0.52
–1.87
+1.18
–2.43
+2.50
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
1991
1992
MONTH

HIGHLIGHTS:

- *More than 5 inches of rain recorded at IAD (5.55"), DAA (5.79), and ADW (5.77);*
- *Over 11 inches of rain measured in LaPlata, MD, including 6.2" from the 4th–7th while Coltons Point recorded more than 9 inches on the 5th–6th;*
- *Tropical Storm Danielle produced more than an inch of rain at four of the five airports from the 25th–26th;*
- *Six of last seven months have been cooler than normal at DCA, BWI, IAD and ADW;*
- *No 90°F or greater readings during month at DCA (the first such occurrence since 1987), with only 21 90°F+ days in 1992 (through September), the least since 1979;*
- *Below normal average temperatures for Jan–Sep period at DCA, BWI, and IAD. In addition, it was the coolest Jan–Sep period at DCA since 1982.*

Andrew H. Horvitz, Office of Meteorology/NWS, 713–1867
Joseph A. Harrison, Climate Analysis Center/NMC/NWS, 763–4670
Ralph E. Meiggs, Satellite Data Services Division, NCDC/NESDIS, 763–8402

Figure 27: First issue of PRESTO (original in color) using color Interleaf software package on an Apollo workstation. Text and graphics are combined to eliminate "cut and paste" technology.

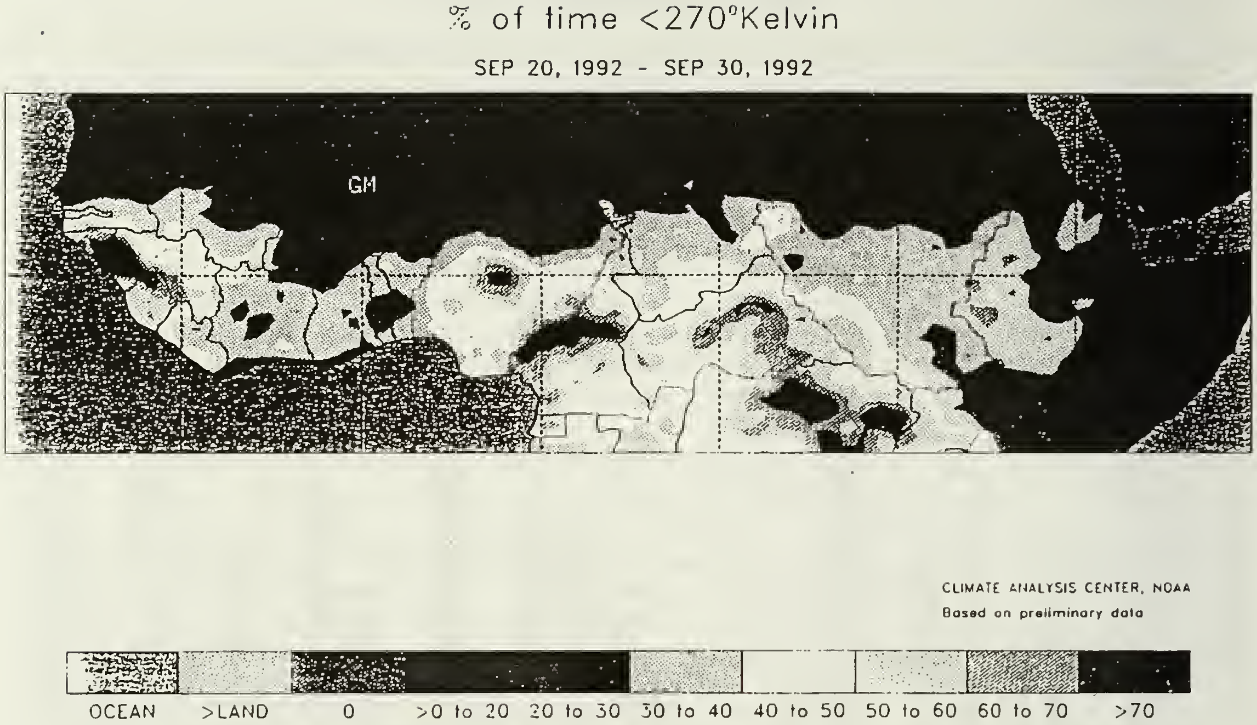


Figure 28: Analysis (normally in color) of the percent of time that METEOSAT Infared cloud top temperatures exceeded 270°K during September 21–30, 1992. This map was used for the possible occurrences of warm cloud top rainfall. The analyzed grid was for every 0.5° from 0–20°N latitude and 20°W–50°E longitude, and satellite temperature accumulations were done every 2 hours for a possible ten-day maximum of 120 (10 x 12 images/day).

20°W-50°E were screened for reported rainfall accuracy and only acceptable stations were included with the satellite estimates. The data were transmitted to FEWS, and will be compared with independent rainfall estimates (University of Reading, U. K.).

Results from another study indicated an underestimation of satellite-derived rainfall estimates compared to monthly AGRHYMET rain data during peak rainy months (June-August). These differences are due likely to unreliable daily rainfall totals, improperly defined Sahel climate zones, and static zonal precipitation equations. There was better agreement during drier months (April, May, and September).

3.1.8 Daily Weather Maps (Dionne)

The production of the Daily Weather Maps (DWM) Series continued, in conjunction with the NMC/Meteorological Operations Division. There is a new printing contractor for the DWM and the standards for accurate registration are being met. Also, all administrative and fiscal functions were accomplished.

3.2 Supporting Projects

3.2.1 Drought and Soil Moisture Indices (Dionne, Heddinghaus)

A near-real-time data set of weekly (and monthly) total precipitation and average temperatures was developed for the 344 contiguous United States Climatic Divisions. The purpose is to replace questionable weekly climate division data that are used in the calculations of the preliminary weekly Palmer Drought Severity Index and Crop Moisture Index. The new method derives temperature values from 730 first-order stations while precipitation data are obtained from approximately 8,100 River Forecast Center and first-order synoptic stations. Comparisons with the monthly historical climatic division data from the National Climatic Data Center (NCDC) indicate better agreement with temperatures, but less agreement with precipitation data which are both received from NWS/Field Offices. Efforts are underway to improve the derived values.

A Soil Moisture Workshop was organized by CAC (June 26) to develop an understanding of the current state of research as well as to determine future priorities. Presentations, which described current research and requirements, attested to the diversity of expertise, interests, and applications. The workshop concluded with recommendations to create a catalog of available research data sets and to develop crop-specific drought indices, crop models, and weekly soil moisture updates. Future priorities include: a summary of available spatial and temporal data resolution, the archival of NEXRAD precipitation data, and the verification of remotely-sensed soil moisture data. There was agreement that more workshops should be held.

3.2.2 Energy Product Development (Heddinghaus, Lehman)

Software was developed to compute weekly and monthly summaries of heating and cooling degree-days for additional stations. The present list includes 358 stations in the United States, Alaska, and Hawaii. A daily average temperature file (1000 days) and a daily normal average temperature file were also created and implemented for the new station list. There are also summaries that contain seasonal accumulations and comparisons with both the normals and the previous year's total.

Calculations of degree-days for the 344 contiguous United States Climatic Divisions are underway along with weekly and monthly summaries for state, regional, and national population-weighted degree-days. Electric customer-weighted cooling degree days and electric, gas, and oil customer-weighted heating degree-days are also being generated regionally and nationally. This new degree-day data base should be completed in early 1993 and will replace the present 20-year old data base.

3.2.3 WMO Support (Laver, Churchill)

CAC continues to provide a significant amount of monthly products published in the WMO World Climate Programme's Climate System Monitoring (CSM) Monthly Bulletin. Rapporteurs (J. Laver, A. Kellie) for the WMO Commission on Climatology/Working Group on Climate Data and the Commission on Basic Systems/ Working Group on Data Management formulated recommendations for the collection, transmission, and tracking of current climate data and products. These recommendations are: 1) to improve summaries and the quality control of CLIMAT/ CLIMAT TEMP data receipts in coordination with NOAA/NCDC; 2) to develop monthly alphanumeric bulletins of principal global temperature and precipitation anomalies for distribution through the Global Telecommunication System or a comparable real-time mechanism; and 3) to determine the feasibility of distributing monthly graphical climate products over the various communications and facsimile systems.

3.2.4 Socioeconomic Impacts (Lehman)

Several interactive software products were developed and distributed to the Regional Climate Centers, government agencies and private users for climate data applications and impact assessment These include programs that: determine the probability of an extreme climate event and the return period for such an event, produce an extreme value analysis of monthly heating degree-days for each state; model natural gas sales as a function of heating degree-days; calculate estimates of degree hours from daily and monthly temperature data; and harmonically smooth periodic climate data.

3.2.5 Climate Services Systems & Communication (Thomas)

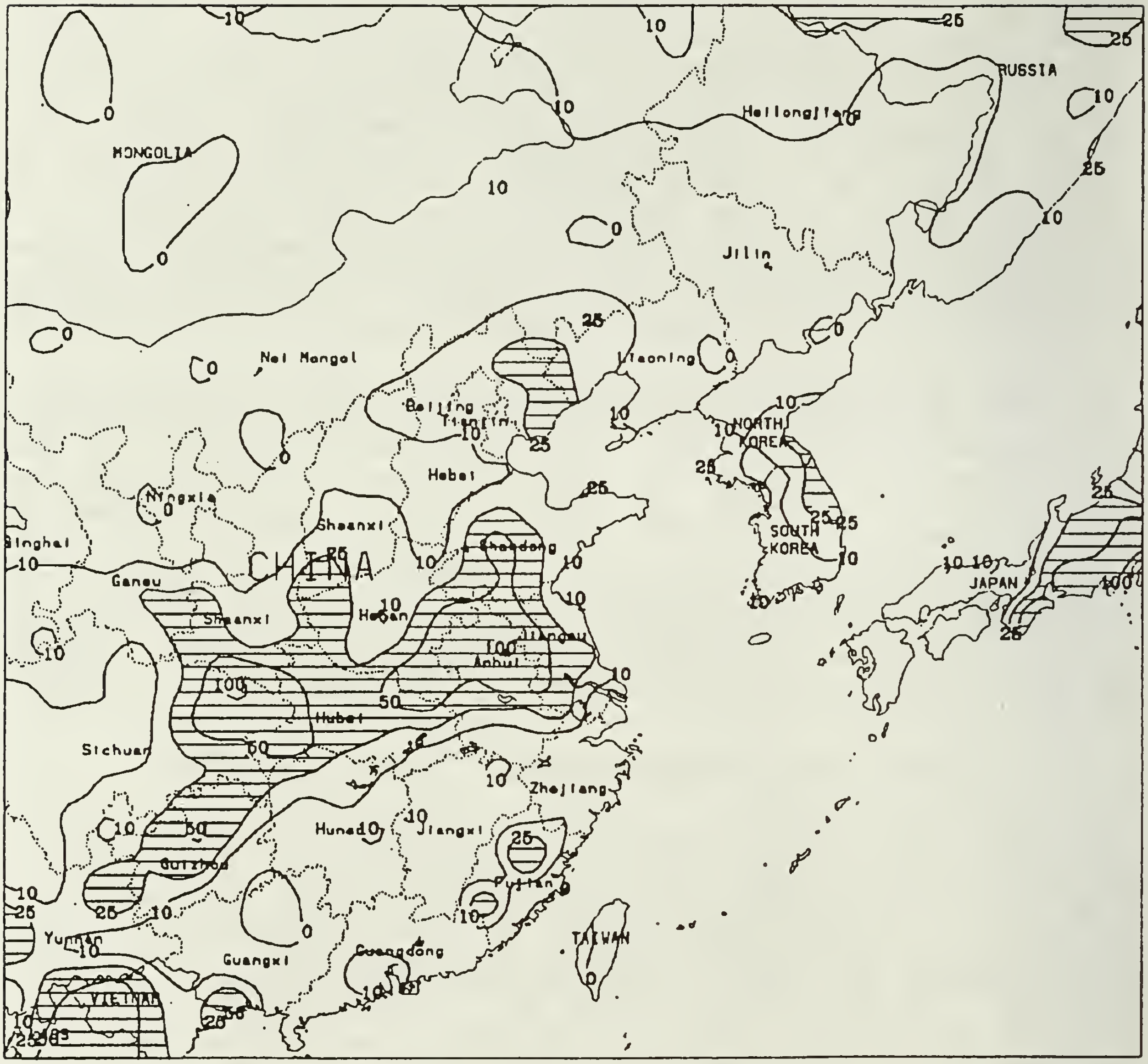
CAC's hardware/communications systems were improved by the following actions: one PC-325 and four PC-486's were added to enhance the office automation, publication, and graphic capabilities; the available disk space on the VAX cluster was increased by two gigabytes; and a DEC Infoserver was implemented to allow on-line access to the VMS documentation and products. The Infoserver will also permit shared access of CD-ROM tape drives, PC's and VAX stations to the stored data. The use of the VAX systems has greatly increased with the workload from the Regional Climate Center Program and Stratospheric Monitoring Project. Operational applications continued with the VAX up and running over 98% of the time. Only one full-time employee maintains the system, with the assistance of three other persons who contribute part-time and back-up support.

Software was installed on the VAX cluster and a limited number of PCs to permit networking. This action enables the use of X-windows from the VAX, UNIX-based workstations, and the CRAY, as well as the use of virtual drives on the PC with the data residing on the VAX, and access to the printers attached to the VAX cluster. A second X-window system was installed that uses Microsoft Windows as a base. In addition, a network print spooler was installed at JAWF and a network color printer was installed in the World Weather Building (WWB), which greatly improved the access and speed of printing color images in the WWB and the availability of monochrome and color output at JAWF.

3.2.6 Contract Software Applications (Miskus, Herman)

Automated publication-quality graphics continued to be improved, with software upgrades and additions implemented to further increase automation and product quality, especially at JAWF. These enhancements include: automated color analysis maps for the U.S. and 12 foreign areas for 4 parameters used in the JAWF mid-week briefings; automated monochrome analyzed maps for the U.S. and 14 foreign areas for 5 parameters (**fig. 29**); modified monochrome labeling algorithm; specialized geography for country, state, province, and crop area boundaries in foreign areas; current country and state names and labels; and improvements to the precipitation analyses, especially for the U.S. Full editing capabilities of the monochrome graphics files on PCs is feasible using a Microsoft package. This is critical for JAWF personnel since their primary workstations are PC's.

The above enhancements have enabled the inclusion of all U.S. precipitation and temperature maps in the Weekly Climate Bulletin, and U.S. temperature maps in the Weekly Weather and Crop Bulletin (WWCB). Incorporation of the automated U.S. precipitation and all foreign area maps into the WWCB is anticipated shortly, which will further increase efficiency.



EASTERN ASIA Total Precipitation (mm)

SEP 30 - OCT 6, 1992

Figure 29: Fully automated monochrome precipitation analysis of Eastern Asia for the week of September 30 – October 6, 1992. All contours and graphics are automatically generated and printed at JAWF and the WWB, and are planned for future inclusion in the Weekly Weather and Crop Bulletin. These maps will replace the current labor–intensive, slow, and antiquated manual analysis and labeling schemes. The maps can also be edited on a PC if necessary and incorporated with the text using desktop publishing sofware.

Other developments included a generalized plotting and analysis program on a workstation to quickly produce special mapped areas of interest, color weekly PDI charts by climate divisions, color hemispheric ozone analysis charts, and revised satellite-derived rainfall software for the African Sahel.

3.2.7 Workstation Project (Harrison, Tinker)

CAC staff have actively participated in the new National Meteorological Center's Workstation Group. At least one of six individuals (D. Garrett, J. Hoopingarner, R. Tinker, E. O'Lenic, J. Harrison and A. Lessard) attends the monthly meetings of the Technical Advisory Board, which advises the Workstation Group Managers (A. Mostek, J. Ward and M. des Jardins) on how to best serve the current network of Sun and SGI workstations and on what direction to take the evolution of the next generation of workstations, networking, and software. Three individuals (J. Hoopingarner, J. Harrison, and D. Garrett) participate in the development of the next generation of software and networking.

The Technical Advisory Board has guided the Workstation Group toward the use of default formats and dividing the current ring of 50 workstations into a few separate rings to improve communication between nodes. CAC participants in both groups have tried to provide beneficial input for the Workstation Group Managers, while at the same time, keep the Climate Analysis Center requirements in mind. Workstation requirements are being documented that address several projects within each Branch.

3.2.8 Solar Radiation Network (Yang, RCCs)

The Solar Radiation Monitoring Network (SOLRAD) received support by interim funding from the National Weather Service, NESDIS, and the Office of Global Programs. Contract scientists were commissioned to evaluate and monitor data quality and transmission. Since June 1992, the data dropout rate has been reduced from 10% to 5%. In addition, a modification to the data acquisition procedure in the CAC Dial-Up Service has increased the amount of data.

A pilot study was performed (S. Katz, contractor) to evaluate the possibility of using the solar radiation data that are recorded on NESDIS/Data Collection Platforms as a supplement for SOLRAD. It was found that only six stations had proper reports, and three of them could be useful as a backup site. It was determined that no further action should be taken at this time.

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4. AGRICULTURAL SERVICES

4.1 Operational Products

4.1.1 Weekly Weather and Crop Bulletin (LeComte)

The production of the Weekly Weather and Crop Bulletin continued with emphasis on fully automated analyses of weekly data for the U.S. and foreign countries. Special articles were written that provided insights and updates on Hurricanes Andrew and Iniki, as well as the ENSO warm event. Another article focused on the striking similarity between the wet, cool summers of 1992 and 1915, as shown in **figure 30.**

4.1.2 Agricultural Briefings (LeComte)

CAC meteorologists at the NOAA/USDA Joint Agricultural Weather Facility continued to keep crop analysts informed of weather events over the major global agricultural areas through daily and weekly briefings. Automated color precipitation and temperature maps were used which enhanced the quality of the presentations and considerably reduced the preparation time. During early 1992, the crop analysts continued to be updated on the progress of the ENSO event and its potential impact on global agriculture. Other highlights included the drought in southern Africa and northern Europe, and heavy rains in the U.S. Midwest, Argentina, France, and Pakistan.

4.2 Supporting Projects (Laver, Lecomte)

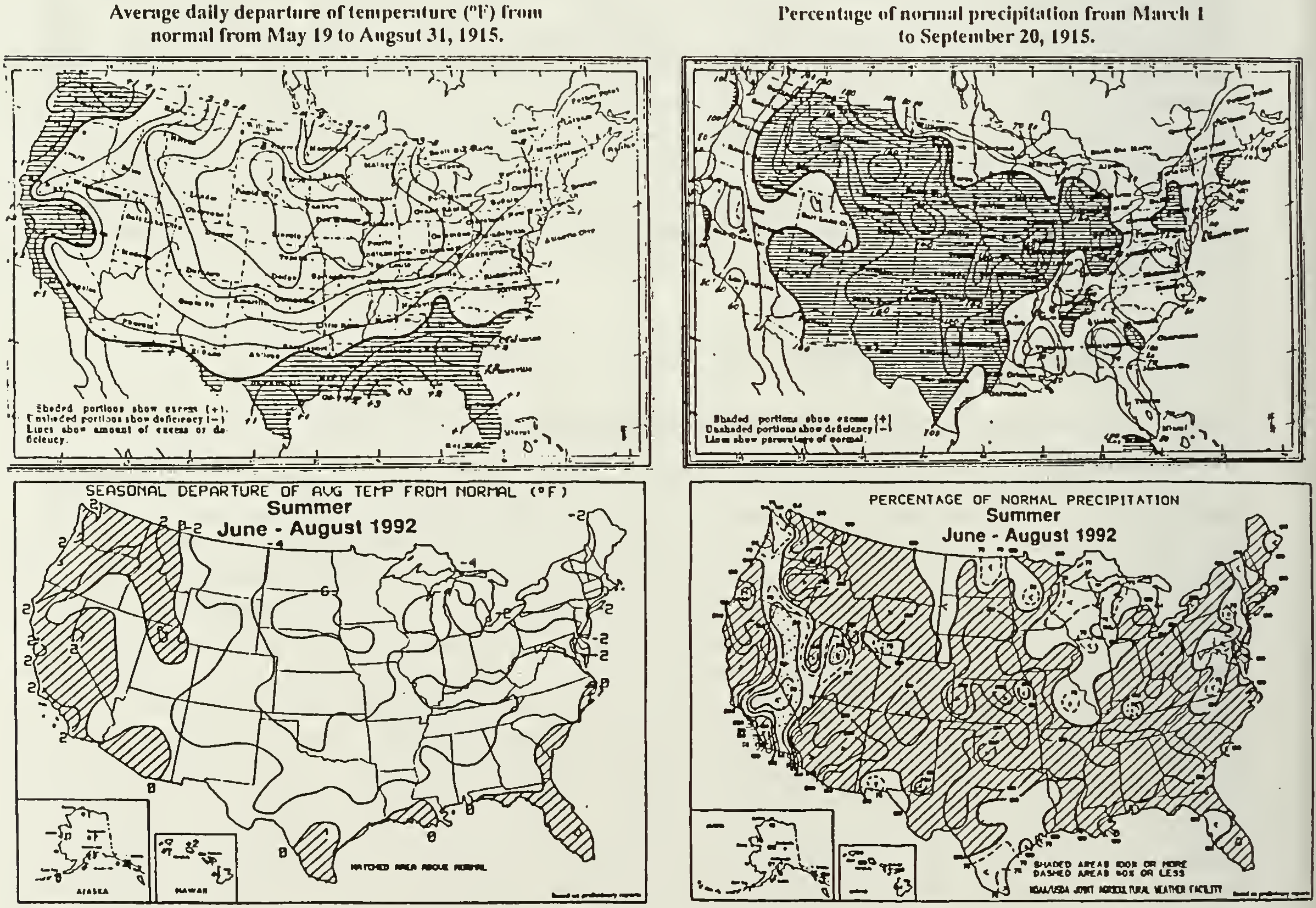
4.2.1 Climate/Agricultural Assessment (LeComte)

Climatic fluctuations resulted in large crop production gains for the United States, but led to losses for other regions of the globe. Abundant July rainfall eased drought concerns in the U.S. corn belt; although delayed plant development, due to the cool summer, increased the possibility of a damaging fall frost. As of late September, U.S. farmers were expected to harvest record yielding corn crops. The cool North American growing season had more of an adverse impact on the Canadian crop yield potential. In Europe, summer heat and dryness hurt crops, while severe drought withered crops across southern Africa early in 1992, with South African corn production the lowest since 1952. In contrast, the Asian monsoon supplied adequate rain to farmers in southern and southeastern Asia. Overall, global wheat production for 1992-93 was forecast by the USDA to be down 3%, with coarse grains down 4% and oil seeds up 3%, compared to the 1991-92 growing season.

4.2.2 Special Agricultural Interactions (Laver)

An extensive briefing was given to members of a team investigating potential support for the U.S. AID/Famine Early Warning System (FEWS) Project - Phase III, which is expected to begin in January 1994. The presentation showed current and potential support for FEWS and the potential benefits of a CAC African Desk, which could receive funding from other sources.

A limited data and product exchange has been proposed between Earthsat Corporation's Cropcast subsidiary and CAC. The purpose is to explore quality control techniques, product accuracy, and the possibility of avoiding duplication of selected labor-intensive operations. Cropcast demonstrated its technique for determining rainfall estimates by combining satellite imagery with conventional summarized surface data.


Average daily departure of temperature (°F) from normal from May 19 to Augsut 31, 1915.

Percentage of normal precipitation from March 1 to September 20, 1915.

SEASONAL DEPARTURE OF AVG TEMP FROM NORMAL (°F) Summer June - August 1992

PERCENTAGE OF NORMAL PRECIPITATION Summer June - August 1992

Shaded portions show excess (+). Unshaded portions show deficiency (−). Lines show amount of excess or deficiency.
Shaded portions show excess (+) Unshaded portions show deficiency (−) Lines show percentage of normal.
HATCHED AREA ABOVE NORMAL
ALASKA
HAWAII
SHADED AREAS 100% OR MORE
DASHED AREAS 50% OR LESS
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY

Figure 30: Graphics from a late summer Weekly Weather and Crop Bulletin article which focused on the similarity between the wet, cool summers of 1992 and 1915.

5. REGIONAL CLIMATE CENTERS

5.1 Project Office Activities

5.1.1 Management and Coordination (Bermowitz)

The RCC/Project Office at CAC reviewed all 6 grant proposals for the funding of RCC operations, services, and applied research and forwarded each proposal with associated administrative material to the NOAA/Grants Office for approval. The RCC/Project Office at CAC also provided support to: the Southeastern RCC for a climate services initiative for the Caribbean; the Southern RCC for a Gulf of Mexico Data Workshop; the Western RCC for an effort to incorporate Alaska and Hawaii into that Center, and the Midwestern Center to lead a project that will standardize hardware and software at all RCC's.

Three-Year Strategic Plans describing the operations, management, and applied research were prepared by the RCCs. These plans underwent regional review as well as national-level review at the CAC and the National Climatic Data Center. An RCC Budget Initiative for FY 94 was written to enhance the development of the RCCs as an important element of a NOAA Climate Services Program. This initiative also proposed an improvement to the NOAA SOLRAD Network. A Newsletter was initiated at CAC to provide news about the RCC Program and is sent to each RCC.

Site reviews of all six RCCs began in July 1992, with the first review at the Southeastern Center. An independent group (led by by S. Changnon) is reviewing all aspects of the operations, services, applied research, and management of each RCC. The review of all 6 Centers should be completed in 1993.

Efforts continued toward the goal of integrating the RCCs within the National Weather Service. The Directors of the Northeastern and Southeastern RCC's and the Executive Officer of the RCC Project Office at CAC attended a NWS/Eastern Region Area Managers Meeting held in Sterling, Virginia. A description was provided on the RCC Program and how the RCC's could help the NWS Field Offices. One result has been a marked increase in the number of requests (NWS referral) for data at the Northeast RCC.

5.2 Operations and Services

5.2.1 Climate Data, Products, Services (Bermowitz)

The RCCs continued to increase their data bases by adding hourly observations for first-order weather stations and archiving high resolution precipitation data, state and local area network data, and RAWS data. At the request of the Soil Conservation Service (SCS), all RCCs took part in a survey of soil moisture and temperature monitoring sites in their regions.

Operational Climate Dial-Up Systems were implemented at 3 RCCs and enhancements to existing systems were made at 2 others. All RCCs now have this capability which is vital for a climate services program, since it provides a direct link by external users to RCC data bases. The RCCs continued to prepare weekly and monthly regional climate impact statements and to answer all data requests. A Monthly Climate Impacts Statement from the Northeast RCC was implemented on AFOS (in July), after coordination with NWS/Eastern Region HQ. It is planned to obtain impact statements from the other RCCs for AFOS dissemination.

5.3 Special Projects

5.3.1 Regional Research Activities (Bermowitz, Robinson)

The RCCs engaged in a number of internal research and development activities and funded extramural research projects. A summary of research studies included: the characterization of regional climate and climate variability, impacts of climate variability, the development of new data and information products, rainfall frequencies and return periods, ozone climatology, tornado climatology, the development of drought indices, drought monitoring strategies, corn and soybean yield estimate modeling, improved understanding of the sensitivities of agriculture to climate, interactions between circulation anomalies, climatology of the Gulf of Mexico, and improved accessibility to the RAWS data set. A volume of selected papers, describing RCC-related research, was assembled for publication by the Executive Officer/RCC Project Office at CAC.

The first Visiting Scientist of the RCC Program is Professor Peter Robinson from the University of North Carolina. In addition to performing work on his research proposal "Great Lakes Synoptic-Scale Precipitation," Dr. Robinson is also assisting the Executive Officer of the RCC Project Office on peer review process of R & D proposals from the RCC's.

5.3.2 NEXRAD Climate Precipitation (Laver, Katz, RCCs)

As radars under the NEXRAD Program are deployed by the NWS across the U.S., a whole new data set is becoming available for climate studies, for example, in agriculture and water resources. This data set will benefit from high spatial resolution observations of quantitative precipitation at intervals ranging from minutes to 1 day. Procedures are being considered at CAC to access and store the data, determine its accuracy, and develop a data base for long-term summaries in cooperation with the RCCs, NMC/Meteorological Operations Division, NWS/Office of Hydrology and the National Climatic Data Center. Each group will want applications tailored to its specific needs and will be able to tap an efficiently designed data base with coordinated quality control and sophisticated procedures.

6. STRATOSPHERE AND TRACE GASES

6.1 Operational Products

6.1.1 Temperature (Gelman)

Stratospheric analyses at eight pressure levels, 70 to 0.4 mb, are produced daily and disseminated for a wide variety of operational and research applications. The analyses are derived operationally using rawinsonde and NOAA-11 satellite sounding data. Continual monitoring of the input data and the analyses is performed to maintain the highest quality product. It is gratifying that CAC's stratospheric analyses are being used to provide a standard for extensive comparisons of data from various instruments on the Upper Atmosphere Research Satellite (launched September 1991).

6.1.2 Winds (Long)

The CAC is comparing derived winds from its operational stratospheric height fields with those observed by the High Resolution Doppler Imager (HRDI) instrument on board the Upper Atmospheric Research Satellite (UARS). The HRDI instrument measures winds from 15km to 45km in the stratosphere (100mb to 1mb). In this initial stage the balanced winds derived from the CAC product are being used to give guidance to improving the HRDI wind algorithm. It is a future goal that the HRDI winds will be the standard and will be used for guidance to CAC-produced wind fields and their associated height fields.

6.1.3 Atmospheric Angular Momentum (Kann)

Two substantial improvements were made to the Sub-Bureau data base. First, atmospheric angular momentum components from the European Centre for Medium-Range Weather Forecasts are transmitted over the GTS and are now received in near real-time at CAC. These data sets contain analysis values at an increased resolution of 6-hour intervals, instead of the 12-hour intervals in the previous data sets. Secondly, the NMC also produced analyzed angular momentum values at 6-hour intervals at the start of EPOCHS92, a major international campaign to study the high-frequency behavior of the Earth's rotation.

An initial evaluation of these enhanced datasets showed that the angular momentum terms that excite changes in the three dimensional Earth rotation vector are seen to contain important sub-daily information. In particular, the wavenumber-1 dependent equatorial wind-based terms, related to polar motion contain a signal with peaks in one component (chi-2) at 0000 and 1200 UTC, indicating the importance of all four synoptic times.

This signal, likely tidal-related, is even more strongly seen in a comparison of the vertically-integrated functions from the European Centre with those from CAC. This is thought to be due to the fact the European Centre functions are integrated to a higher stratospheric level. Efforts are now underway to compute these functions at CAC in the same way, so that model levels are used in place of pressure analyses. It is anticipated that this will increase the amplitude of the terms produced by CAC.

6.1.4 Ozone (Nagatani)

Daily analyses of TOVS-derived total ozone data continue to be produced operationally for use in monitoring. **Figure 31** shows the ozone values from these maps in the south polar regions during the Southern Hemisphere spring. The plotted curve for 1992 shows the formation of an early season ozone hole at the end of August, which is the earliest formation of the ozone hole for all years of the TOVS record. The curve also shows that the ozone values almost recover to values comparable to 1991, but remain at levels below 1991 until October.

SBUV/2 data are being analyzed periodically and will continue in this mode until a best or final retrieval algorithm is calculated. In the meantime, specific events such as the Arctic or Antarctic "ozone holes" are being monitored with the analyzed SBUV/2 data. Comparisons between SBUV/2 and ground-based data are being made as each version of data is produced. Also, an evaluation is being performed on ozone data that are derived from various sounders aboard the Upper Atmospheric Research Satellite. Data from these instruments are being intercompared and are used to evaluate the SBUV/2 data.

6.1.5 UV-B Forecasts (Miller)

The CAC has initiated discussions with the Environmental Protection Agency on the feasibility of establishing a general public forecast system of ultraviolet radiation at the ground. This would be part of an overall examination of the surface ultraviolet radiation as well as an attempt to sensitize the public to the preventive measures that they can take for long-term health considerations. This system, if approved, would use the NMC forecasts to provide ozone and cloud information to help determine the threat level of high ultraviolet radiation.

6.1.6 Aerosols (Long)

A study on the short climatology of aerosols in the troposphere and stratosphere was initiated for the purpose of monitoring the volcanic aerosols injected into the stratosphere by Mt. Pinatubo. Based on the NOAA/AVHRR Aerosol Optical Thickness (AOT) product (developed by NOAA/NESDIS), a weekly chart is

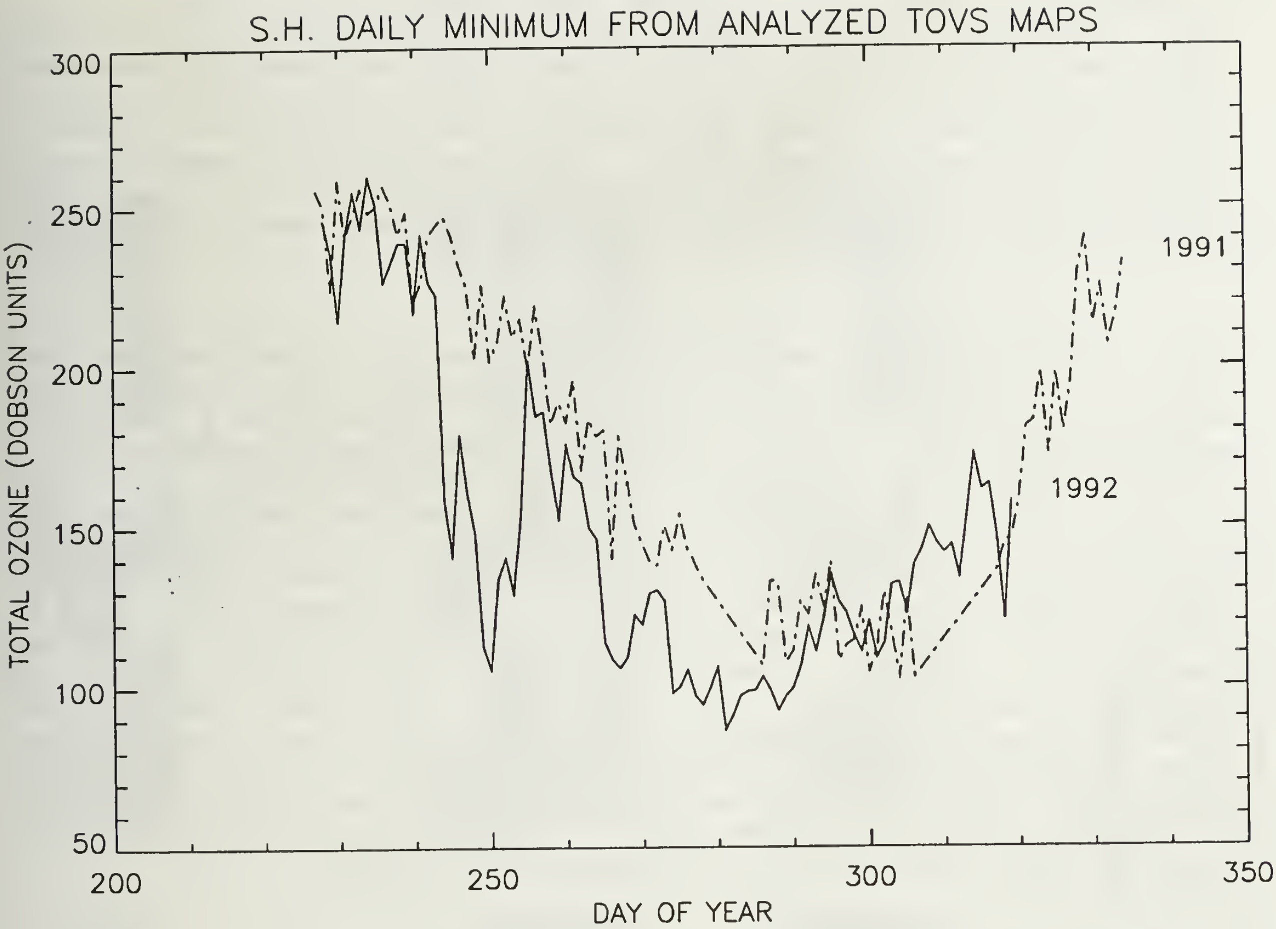


Figure 31: Minimum Southern Hemisphere ozone values from daily analyzed TOVS maps for August 15 to November 30, 1991 (dashed line) and 1992 (solid line).

produced with grid boxes colored according to AOT value. Also, zonal averages of each week's AOT field are being graphically displayed in a latitude versus time chart and monthly-averaged values are being mapped in a equal latitude/longitude grids. Two years of pre-Pinatubo AOT values have been used to create a "background" aerosol reference. The post-Pinatubo weekly zonal and monthly grid amounts can then be subtracted from this reference in order to study the latitudinal movement of the stratospheric aerosols and their dispersal with time.

The evolution of stratospheric aerosols, using the above products, shows that immediately after the Mt. Pinatubo eruption there was a small increase of AOT throughout both hemispheres; however, almost all of the aerosols were confined to a band from approximately 20N to 20S. From September through December 1991, this band slowly broadened in the Northern Hemisphere. For some reason, yet to be determined, the 20S barrier never weakened. AOT values poleward of 20S also increased due to the Mt. Hudson eruption in August 1991. These aerosols filtered out quickly over several months because they were not injected to as high an altitude as those from Mt. Pinatubo. Poleward of 30N, increased amounts of aerosols started to appear in December 1991 and reached a peak in May 1992 (**fig. 32**). The AOT values never showed as large an increase between 20N to 30N, an area presumed to be a transport zone between the equator and mid-latitudes. Since May 1992, the AOT at all latitudes has shown a steady decrease. It is projected that pre-Pinatubo levels will not be reached until the Fall 1993 - Spring 1994 period.

6.1.7 Winter Bulletins (Gelman)

The first annual Antarctic Winter Summary for 1991 and the Northern Hemisphere 1991-92 Winter Summary were produced and disseminated to 300 users. These publications represent a coordinated NOAA effort, with contributions from CAC, ERL, and NESDIS. The Summaries include selected indicators of stratospheric climate to describe the ozone and temperature changes in the Southern and Northern Hemispheres, with comparisons of 1991-1992 events to previous years since 1978.

Current Antarctic lower stratospheric conditions continue to be of special interest. These conditions are being monitored by the ozone infrared sounders onboard the NOAA operational satellites. There was a early start of ozone depletion over the Antarctic, and by the end of September 1992, the area of the "ozone hole" was the largest ever reported. So far in 1992, lower stratospheric temperatures over the Antarctic were close to the long-term average. **Figure 33** shows that the these temperatures were slightly below average during July to mid-August and near average through September. These temperatures are consistent with the low ozone values since these conditions are sufficiently cold for polar stratospheric clouds to form and enhance ozone destruction through heterogeneous chemistry.

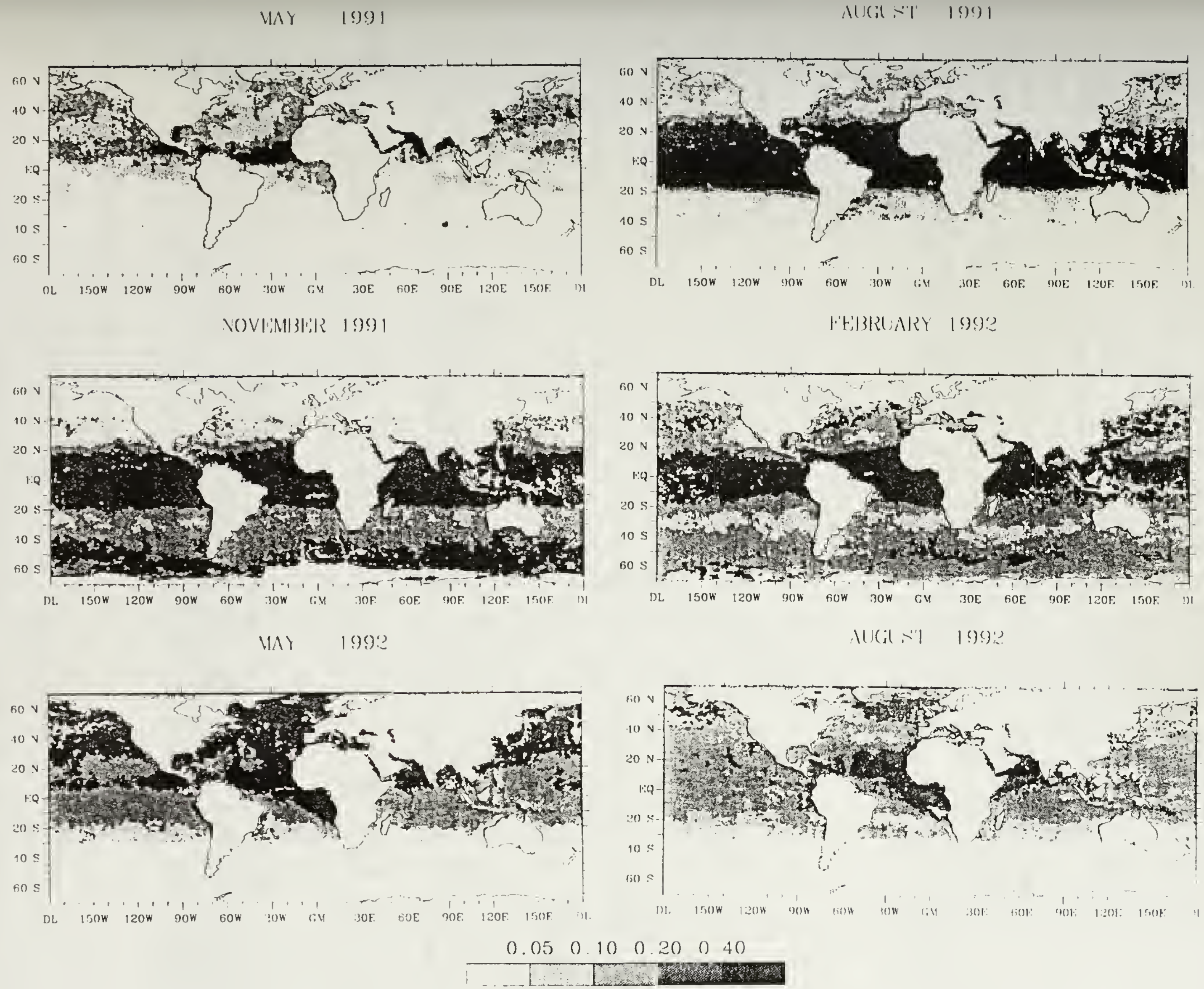


Figure 32: Monthly averages of the NOAA/NESDIS AVHRR Aerosol Optical Thickness (AOT) product. Conditions before the Mt. Pinatubo eruption are shown in the May 1991 image. The succeeding five images show how the aerosols were initially confined to the tropics and eventually spread throughout both hemispheres. The thinning out of the aerosols starts to be apparent by May and August 1992.

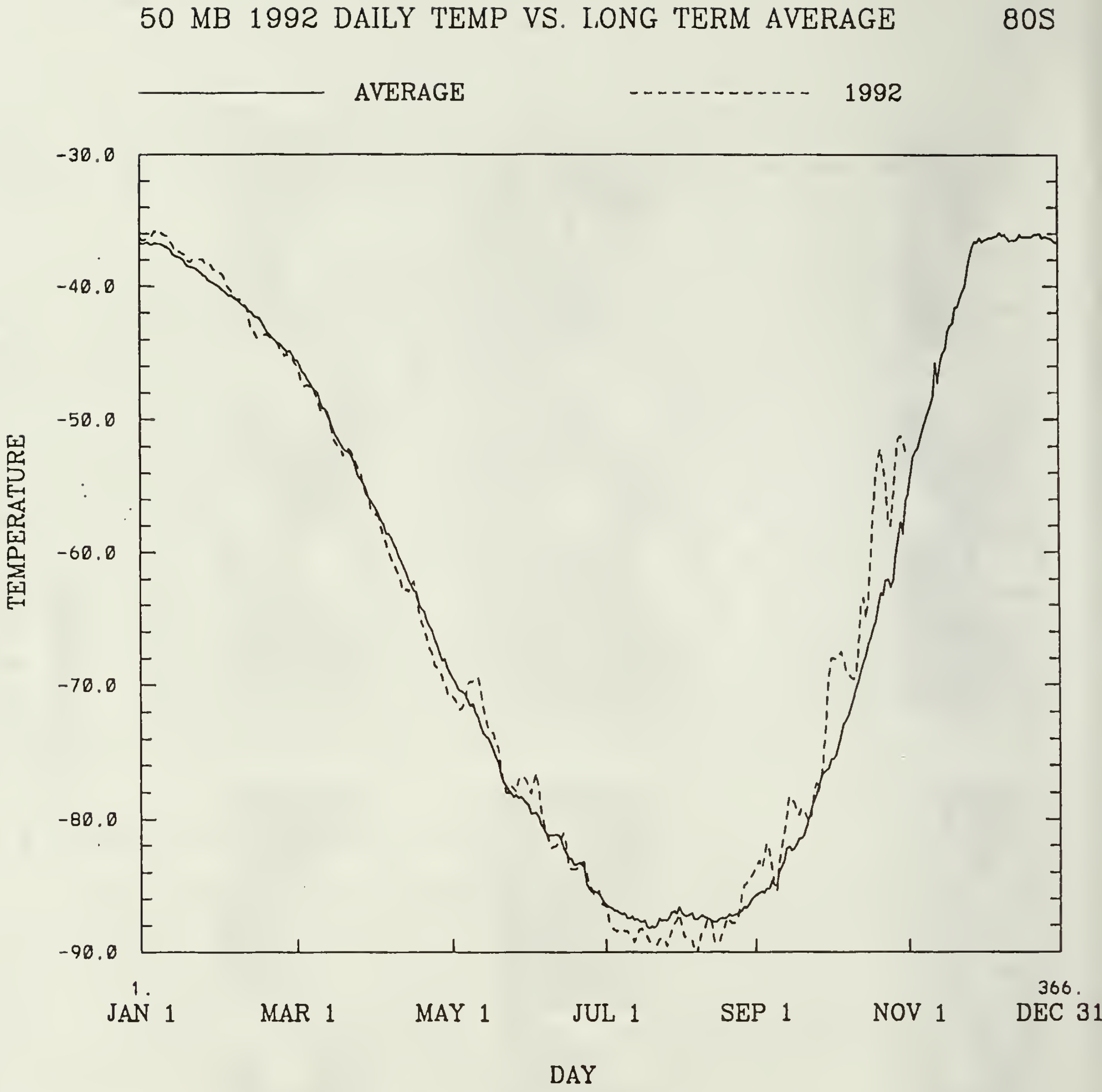


Figure 33: Temperature (C) averaged around 80S latitude for 50 mb. Daily values of zonal mean temperature shown are representative of the lower stratosphere. Solid line shows 1992 values, while dots are the 1978 to 1992 average values for each day.

6.2 Trends

6.2.1 Ozone Trends (Nagatani)

This joint project (with Drs. G. Tiao, University of Chicago; G. Reinsel, University of Wisconsin; and D. Wuebbles, Lawrence Livermore Labs) continues in the investigation of ozone and temperature trends. Seasonal trends of ozone (including total ozone) and temperature are being examined, as well as data from sources other than ground-based data. There is now a record of stratospheric analyses (up to 0.4 mb) since October 1978, corresponding closely with Nimbus-7/SBUV data that are available from November 1978 - December 1990. NOAA/SBUV-2 data are also available from March 1985 to the present. Although these data are at higher altitudes than those from ozonesondes and radiosondes, it is planned to examine the satellite-derived ozone and temperature trends and relationships in the same way.

6.2.2 Temperature Trends (Gelman)

Determining stratospheric temperature trends is important for assessing predicted climate changes due to the increases in atmospheric carbon dioxide and decreases in stratospheric ozone. Evaluations of the stability of CAC's stratospheric analyses for determining temperature trends are being made by comparisons with radiosonde, rocketsonde and lidar data. A paper, written and accepted for journal publication, describes comparisons made between the ground-based data and the CAC upper stratospheric analysis temperatures. Adjustments were derived, based on these comparisons, to compensate for biases introduced each time there was a change (ten since 1978) in the TOVS operational satellite. In order to use the upper stratospheric temperature trends inferred from the CAC analyses, adjustments to the temperature and uncertainty of those adjustments must be fully documented.

In another study, lower stratospheric temperature conditions are being closely monitored, especially after the eruption of Mount Pinatubo, Philippines in June 1991. **Figure 34** shows the progression of zonally-averaged (10S) daily 30-mb temperature for 1991-1992 relative to the long-term (1978-1992) average. After the eruption, tropical 30-mb temperatures increased dramatically, reaching 2C above average by September 1991, and remaining above the long-term average until May 1992.

6.3 Special Projects

6.3.1 Upper Atmosphere Research Satellite (Miller)

Major intercomparisons were initiated for stratospheric products derived from NOAA operational satellites, the Upper Atmosphere Research Satellite (UARS), and ground-based data. This includes ozone, temperature and wind profile information.

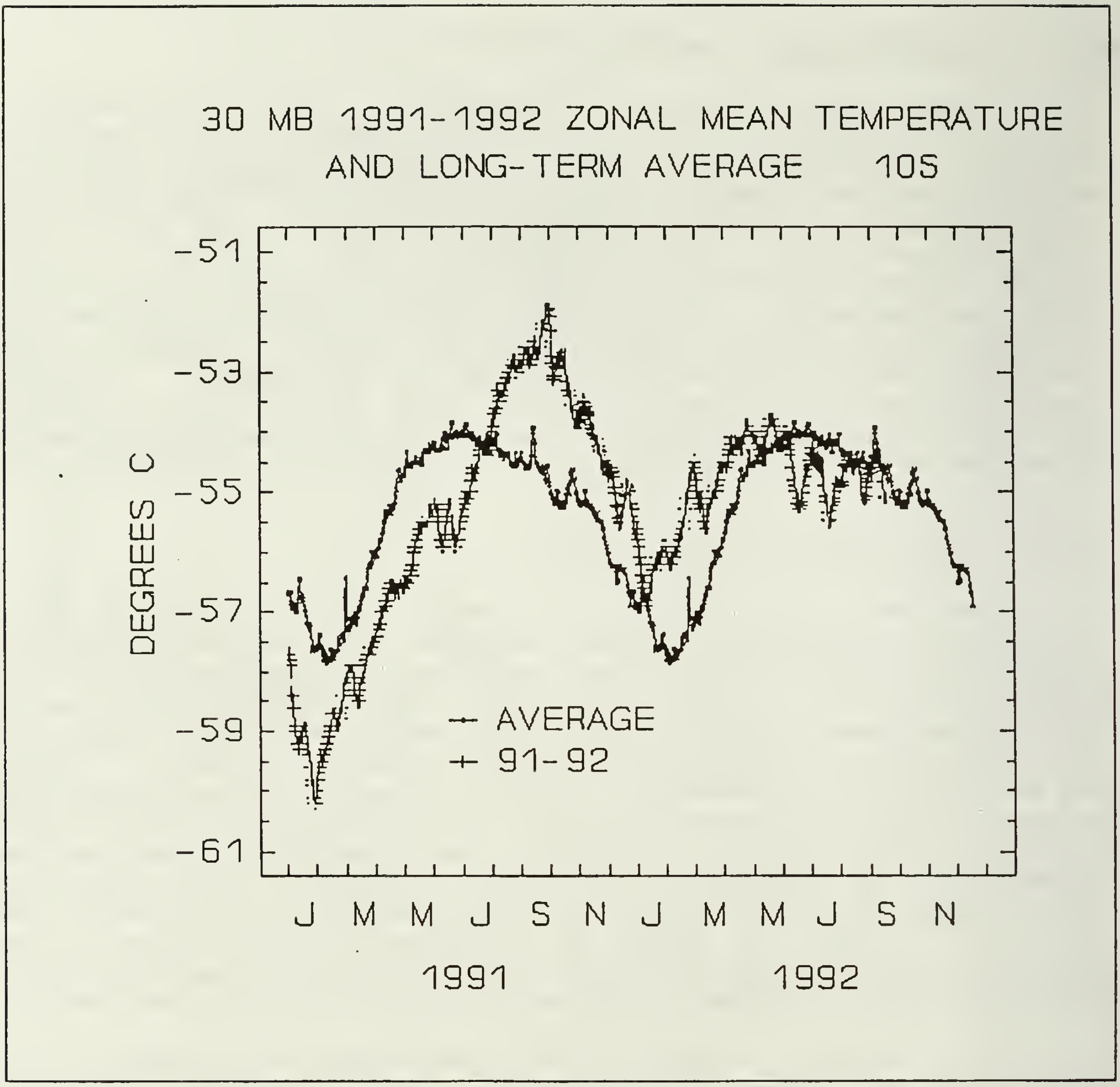


Figure 34: Temperature (C) averaged around 10S latitude for 30 mb. Daily values of zonal mean temperature for 1991 and 1992 (+ marks), compared to the long-term 1978-1992 average daily values (solid line).

First results indicate that the mid-stratospheric temperatures derived from the NOAA satellites may have a cold bias of several degrees, whereas the mid-stratospheric ozone values may have a bias as high as 5-10%. These results are being examined further as to possible causes and, especially, possible effects as a function of time. Stratospheric winds from UARS Sounders appear to have problems with underlying cloud surfaces. CAC is supporting NASA's Science Team in the evaluation of all data.

6.3.2 ERBE/CERES (Yang)

A study was conducted for the Taiwan Area Mesoscale Experiment (Intensive Observation Period No. 11) to investigate the cross-scale utilizations of the cloud parameterization in the NMC/Experimental Mesoscale Spectral Model and the Medium-Range Forecast Model. Cloud analyses from the U.S. Air Force real-time nephanalysis and satellite imagery are being used for validation. The results indicate that the diurnal cycle of the land/sea breeze can be realistically simulated and that the resolution of the nephanalysis is statistically marginal for mesoscale validation.

In another study, intercomparisons were made between OLR from ERBE observations and AVHRR estimates (1985 to 1988). The results showed that the characteristics between the OLR from both instruments persist over various geographical surfaces. Regional difference within the tropics increased after 1987, with OLR values from ERBE higher than those from AVHRR at most longitudes due to changes in the spacecraft. It was also found that seasonal cycles of the zonally-averaged OLR differences are a function of the solar angle.

ERBE-derived mean meridional transport of energy in the earth-atmosphere system has been enhanced by a refined numerical method for the polar regions. For the annual mean energy transport from net radiation, it was found that the computational stability is sensitive to the treatment of missing data.

6.3.3 SAGE II/SAGE III (Nagatani)

CAC continues to provide NASA with height and temperature profile data at SAGE II ephemeris points for deriving daily satellite ozone retrievals. Also, comparisons between SAGE II and SBUV/2 data have shown differences at high latitudes.

6.3.4 Network for the Detection of Stratospheric Change (Wild)

In support of the Network for the Detection of Stratospheric Change, an examination was started for lidar temperature and ozone data from various sites. Temperature data from the French stations at Observatoire d'Haute Provence (OHP) and

Centre d'Etudes des Landes (CEL) have been analyzed. These stations contain the longest-term record of data (OHP from 1978, and CEL from 1986). The average difference between the lidar at a station and NMC analyzed temperatures (interpolated to the site) have been calculated and the results were plotted as a function of pressure. Although the shape of the resulting curves is similar for the two stations, there is a bias in the difference curves of 1 to 1.5 degrees between the stations.

Similar studies of lidar ozone data have been made using SBUV2 as the comparison data set. The longest records of lidar ozone data are available from OHP and from Table Mountain (TMO). The average difference curves for these sites agree within the error bars. Additional long-term data sets are being collected for analysis.

6.3.5 Stratospheric Systems & Communication (Thomas)

In support of CAC's Stratospheric Monitoring Program, a new Digital Equipment Corporation VAX 4000 Series-300 System was added to the VAX cluster, as part of the Data Host Facility of the Network for Detection of Stratospheric Change (NDSC). Disk space was also increased by four gigabytes on the total VAX cluster along with a DEC/Infoserver to allow on line access to the entire VMS documentation and layered products. In addition, a VAX 4000 Series 200 System has been obtained and will be installed at the Mauna Loa Observatory, Hawaii in November 1992.

Other hardware additions include: four PC 325-386 systems; a thinwire IEEE 802.3 Ethernet multiport repeater; DEC Pathworks, a software product that enables networking of PC's and the use of X windows from either workstations or the CRAY Super Computer; and a second X window system that uses Microsoft windows as a base.

6.3.6 VAX/VMS Data Base for NDSC (Lin)

The purpose of the VAX/VMS data base is to provide a unified data base for the Network for Detection of Stratospheric Change (NDSC) Project. The prototype of the data-base software has been completed and both the data base and the software reside on a VAX 4000-300 system. Interface software has also been implemented and an on-line help system was completed to describe the menu-driven system. In addition, daily NMC temperature-pressure-height profile data are being cataloged both as a comparison standard and as a mechanism for transfer of units to a common standard. So far, the major active NDSC participants are the Observatoire Haute Provence (France) and Table Mt. Observatory (JPL) which are providing daily temperature and ozone lidar data. About two gigabytes of data per year will flow through the system when it is fully utilized, by a projected 50 users.

6.3.7 Stratospheric Data Support (Nagatani, Gelman)

Stratospheric data were provided by the CAC to support the Airborne Arctic Stratospheric Expedition II (Fall 1991 to Spring 1992). Large amounts of ozone-destroying ClO were found in the cold Arctic stratosphere; but, the destructive cycle for ozone did not occur because of a stratospheric warming that took place. Currently, preparations are being made to support the upcoming Stratospheric Photochemistry, Aerosols, and Dynamics Expedition. Preliminary flights are to begin in Fall 1992, with the main expedition scheduled for Spring 1993.

In support of NASA's High Speed Research Project (HSRP), temperature results from two-dimensional model calculations were compared with actual measurements. One of the two main temperature climatologies being used for these comparisons is the NMC climatology. Some of the models calculate their own temperatures interactively and some use climatological averages. Results have been documented and sent to NASA for publication.

CAC is providing stratospheric/tropospheric data and analyses to the Naval Surface Weapons Center (Dahlgren, VA) to help them assess atmospheric effects on their programs. During the past year, emphasis was placed on evaluating the network of stations and data archival for their specialized programs.

CAC completed the data sets to validate TOVS Pathfinder products. This effort involved: the archival of all available 1979-1991 rocketsonde and lidar stratospheric temperature information, format documentation, and software usage. These data sets are required to derive the highest quality TOVS data for this Project for use in the assessment of climate change.

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7. CLIMATE PREDICTION

7.1 Empirical Studies

7.1.1 Seasonal Empirical Prediction (Livezey, Barnston)

An intercomparison among three forecast verification measures (the correlation score, root mean square mean error score, and Heidke score) has been carried out to more clearly document the nature of the correspondence among them under different circumstances. It was found that the Heidke score generally is smaller than the correlation score for the same forecast set and that this increases with increasing number of forecast categories. However, a version of the Heidke score in which the forecast penalties increase with increasing number of categories in error was found to be insensitive to the number of categories scored. A journal note is being written for publication in Weather and Forecasting.

7.1.2 Soil Moisture and Temperature Forecasts (van den Dool, Huang)

The purpose of this project is to improve long-range temperature forecasts through the knowledge of antecedent soil moisture. As a pioneer study, the relationship between monthly mean precipitation (MMP) and temperature (MMAT) was examined, based on both U. S. climate division and station data from 1931 to 1987. MMP was used as a first order proxy for the soil moisture anomaly and the output of 2 multi-year runs of the MRF model was analyzed with and without soil moisture feedback.

A simple, physically-based soil moisture model was set up and a time series of daily soil moisture was calculated and analyzed. Results show that the P-T correlation is generally negative with the maxima in summer and in the interior U.S. continent. The MRF model shows a negative correlation only when soil moisture is interactive (**fig. 35**). It is concluded, therefore, that both the negative P-T correlation (P leading) and temperature persistence (T-T) are enhanced as a result of the creation of soil moisture anomalies.

7.1.3 Multivariate Statistical Prediction (Barnston)

There were significant accomplishments in the long-lead prediction of 1 and 3 month-mean climate anomalies for U. S. temperature. Canonical correlation analysis (CCA), based on forecast products for both time frames, became operational and now supplements existing dynamical and statistical tools. The forecast materials for the prediction of temperature at 59 U.S. stations include: the actual CCA-based standardized temperature

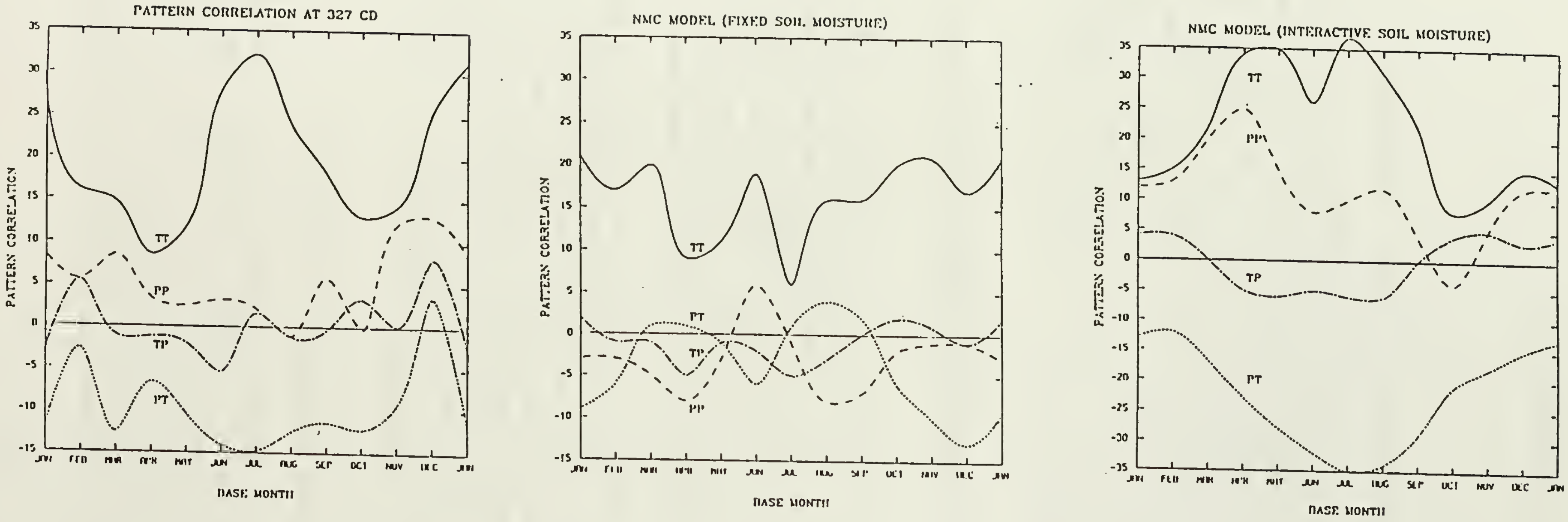

Figure 35: Pattern correlation (%) over the United States at lag one month as a function of the leading month. The four curves are for T-T (solid line), T-P (dashed line), P-P (dotted and dashed line) and P-T (dotted line): (a) observations: the data are for 1931-87 at 327 climate divisions; (b) output of the MRF model with fixed soil moisture; (c) output of the MRF model with interactive soil moisture feed back.

anomaly forecast, damped further for application to an independent forecast year; and a three-class categorical forecast. Two station-by-station historical forecast skill diagnostics are also included: cross-validated temporal correlation skill and a cross-validated Heidke skill score. An ensemble of these materials is produced for each of 5 lead times, which now enables a consistency evaluation to be made among forecasts from differing predictor cut-off times.

A second achievement has been the use of CCA for long-lead seasonal forecasts with lead times extending up to 8 months. These long-lead forecasts were used to introduce a newly created Experimental Long-lead Forecast Bulletin that is disseminated to 100 researchers nationally and internationally.

Experiments were also conducted that used CCA to predict Northern Hemispheric 700-mb height and U.S. precipitation. The results indicate significant skill for the 700-mb height, but only marginally significant skill for precipitation in the southern tier of states in late winter. In both cases, the ENSO is responsible for much of the cold season skill. In predicting both summer temperature in the U.S. and fall temperature in southern Europe, the SST anomaly in the tropical oceans appears to be the governing factor. This newly identified link provides potential for improved future drought/ heat-wave forecasts.

7.1.4 Prediction and Specification Studies (van den Dool)

Some progress has been made in the construction of analogues by combining years linearly to create a good fit to current conditions. An application of this technique has demonstrated that, everything else being the same, constructed analogues outperform natural analogues in the specification of monthly surface weather over the U.S. from hemispheric 700-mb height fields (**fig. 36**).

7.2 Dynamical Methods

7.2.1 DERF - Operational Feasibility Assessment (Tracton, Ebisuzaki)

In collaboration with NMC/Development Division, an experiment was run to assess the effects of horizontal resolution on medium range forecast skill. To be specific, the operational T126 model was truncated to T62 from days 5-10 for comparison with the operational forecast. A key motivation was that if the truncation did not make any difference, then the saved computer time could be used for either upgrading the configuration of the probability experiment or for daily ensembles applicable to the operational 6 to 10-day (medium-range) forecasts.

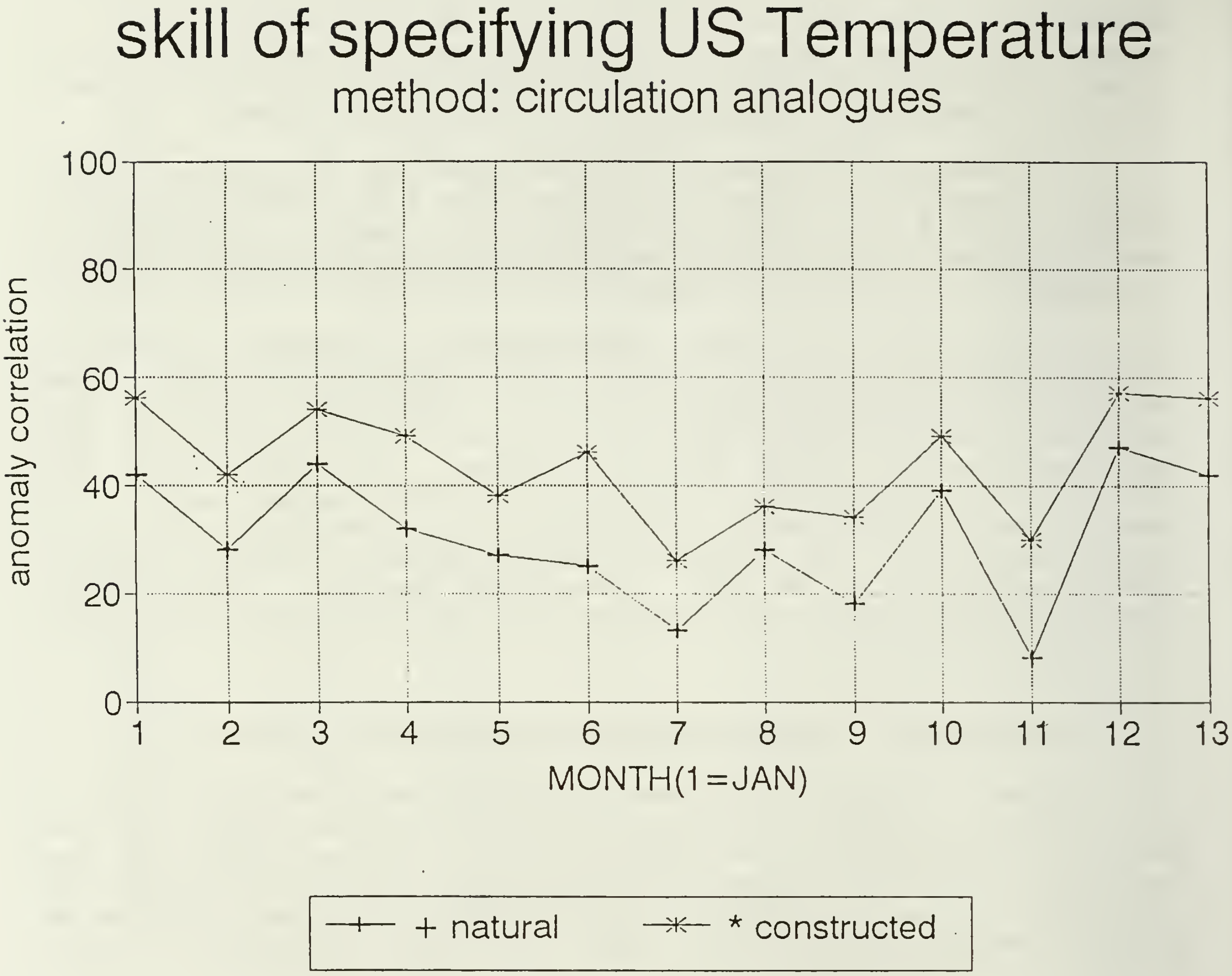

Figure 36: U.S. monthly temperatures have been specified at 344 climate divisions on the basis of similarity to a Northern Hemisphere height analogue. The similarity of the specified and observed U.S. temperature anomalies is measured by the anomaly correlation. Two methods are compared. In the curve labelled "natural", 10 other years are averaged, which are as close to the year to be specified as possible. In the curve labelled "constructed", all other years are combined linearly to obtain a far better forecast to the height field than any natural analogue can give.

The results (documented in a report to the Director/NMC) showed that truncation did no harm (**fig. 37**). Consequently, an agreement was reached to truncate the operational MRF integration at day 7 (not day 5) and use the saved computer time to run 14 - member combined LAF, "breeding" perturbed ensembles that encompass the medium-range forecast period. Details are being addressed with the aim of implementing this major change in configuration and philosophy of the operational suite very soon.

7.2.2 DERF - Regime Dependent Predictability (Tracton)

Detailed evaluation and diagnosis of forecasts continued for selected case studies as the key vehicle to assess the dependence of forecast skill upon circulation regime and especially, regime transitions. Five additional cases have been run, bringing the total number completed to 14. Two of the additional cases involve a major blocking event in the Southern Hemisphere, which will be assessed by G. Bell, CAC. The other three are from an original list that was published in the **Bulletin of the AMS (vol. 72, pp. 1745)**. Additional cases were also selected (in collaboration with R. Dole, NOAA/ERL and K. Mo, CAC) to evaluate whether the near simultaneous occurrences of strong intra-seasonal (30-60 day) oscillations and major Atlantic and Pacific zonal to blocking flow regimes were coincidental or physically related. Each case nominally consists of generating a 9-member LAF ensemble with the T80 version of the MRF. Some cases have been (or will be) rerun with alternative ensemble strategies and model configurations to evaluate the sensitivity of results to factors such as the approach for specifying initial state perturbations, the effects of horizontal resolution, and the influence of boundary conditions.

In addition, a major effort was devoted to producing verification statistics and diagnostic quantities. These include: succinct graphical display of skill scores, measures of forecast versus observed circulation, and procedures for assessing scale-interaction processes and tropical/extratropical connections. Of special interest in the evaluation process is the variability in regime predictability within ensembles, from one case to the next, and those produced at Prediction Centers (e.g., NMC, ECMWF) that are participating in the experiment. A Workshop that will focus on the presentation and intercomparison of results is planned for June 1993.

7.2.3 Probability Forecast Experiment (Tracton)

In this study, 9-member Lagged-Average Forecast (LAF) extended experimental runs continue to be used and appraised, in conjunction with the operational monthly forecasts. Results (verification statistics and diagnostic quantities) suggest that prudent consideration of the forecast ensembles is helpful in the monthly forecast problem. Contributing to these results

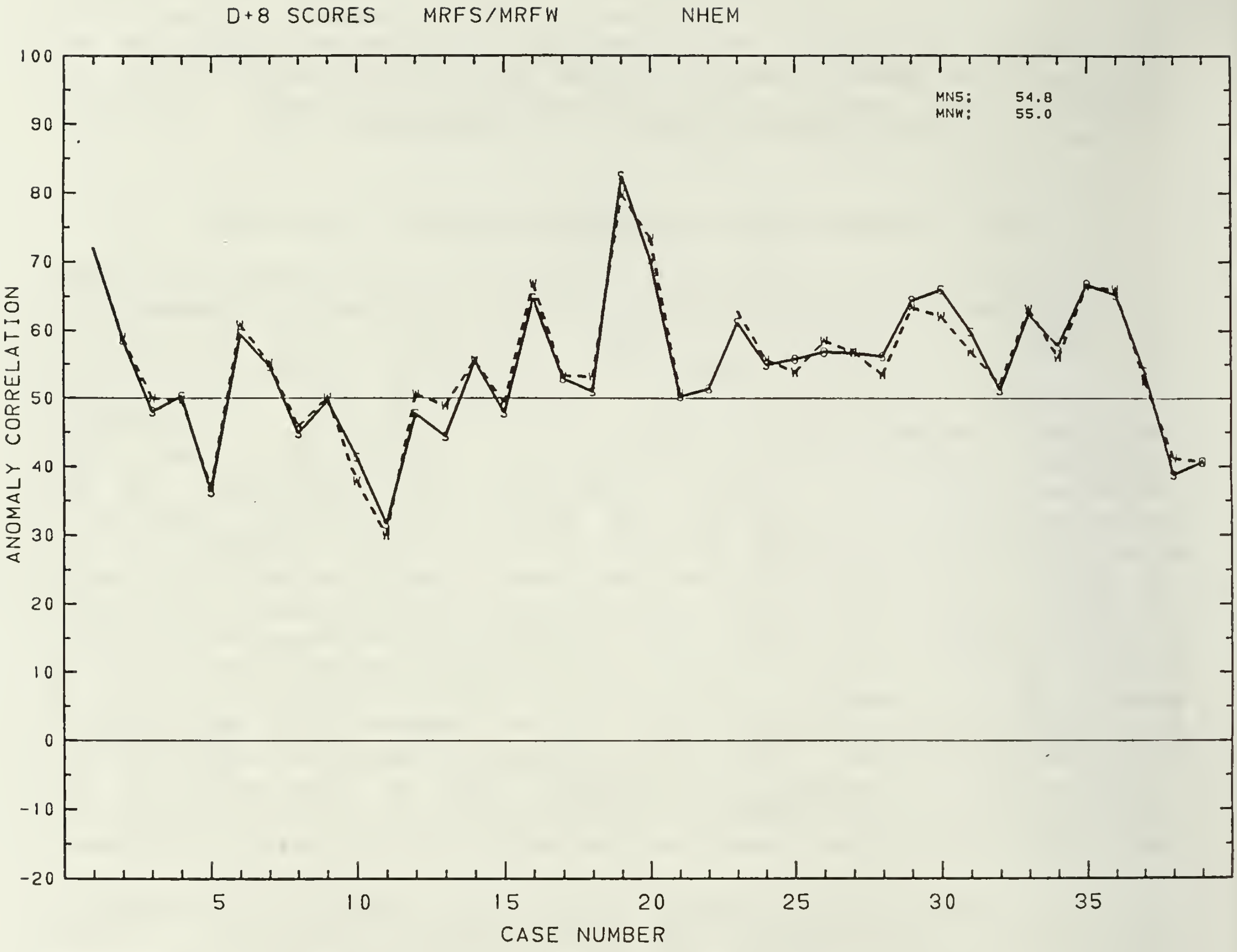

Figure 37: Sequence of Northern Hemisphere anomaly correlation scores for the operational (MRFS), and truncated T126/T62 (MRFW) 500mb height fields (solid and dashed, respectively). Cases 1 to 39 are from initial conditions on February 18 to March 27, 1992.

is the development of a suite of products designed to enhance the operational utility of the ensemble predictions. An evaluation indicates that the ensembles provide generally reliable estimates of the range and likelihood (probabilities) of alternative scenarios (**fig. 38**).

7.2.4 MRF Model Skill Prediction (Chen)

Analyses were performed on DERF experiments to determine relationships between the skill of medium-extended-range forecasts over the Pacific-North America (PNA) region and the fluctuations of the PNA mode of low-frequency variability. Much better skill in both dynamical and persistence forecasts is found for the Pacific sector than the Atlantic sector. The relationships between the polarity and amplitude of the PNA mode and the predictability of the prediction model were also investigated. The results indicate that the PNA mode in the forecasts is a better predictor for forecasting the forecast skill than the PNA mode in the initial conditions.

In a related task, an investigation of Lorenz's 1984 simple, general circulation model uncovered several layers of quasi-periodicity (hidden order) within a chaotic atmosphere. In general, a state of this dynamical system returns to its original neighborhood after wandering about in its attractor space for about 42 days (**fig. 39**). A multitude of attractor patterns are present. A particularly prominent pattern (PB in **fig. 40**) is frequently found to follow another pattern (PA) and is followed by still another pattern (PC). The sequential occurrence of these attractor patterns together with their frequent recurrence leads to a much higher potential for long-range prediction than previously conceived.

7.2.5 MRF Model Behavior and Predictability (Chen)

The 10-year MRF integration runs (performed by van den Dool et al, 1991) were analyzed for characteristics of low-frequency, large-amplitude anomalies. Although the geographical distribution of means and variances shows a gross resemblance between the model and the real atmosphere, careful examination reveals distinct regions where short-term climate anomalies have a tendency to develop. In the modeled atmosphere, large positive anomalies tend to occur over an area south and east of observed ones (**fig. 41**). In the case of large negative anomalies, the modeled results show no resemblance to the real atmosphere, as the modeled-anomalies develop over the Barents and Kara Seas instead of the North Atlantic (**fig. 42**). However, the model does have the capability to persist short-term climate anomalies as long as observed ones, and in some cases longer. In particular, the model maintains large negative anomalies twice as long as those observed in the atmosphere.

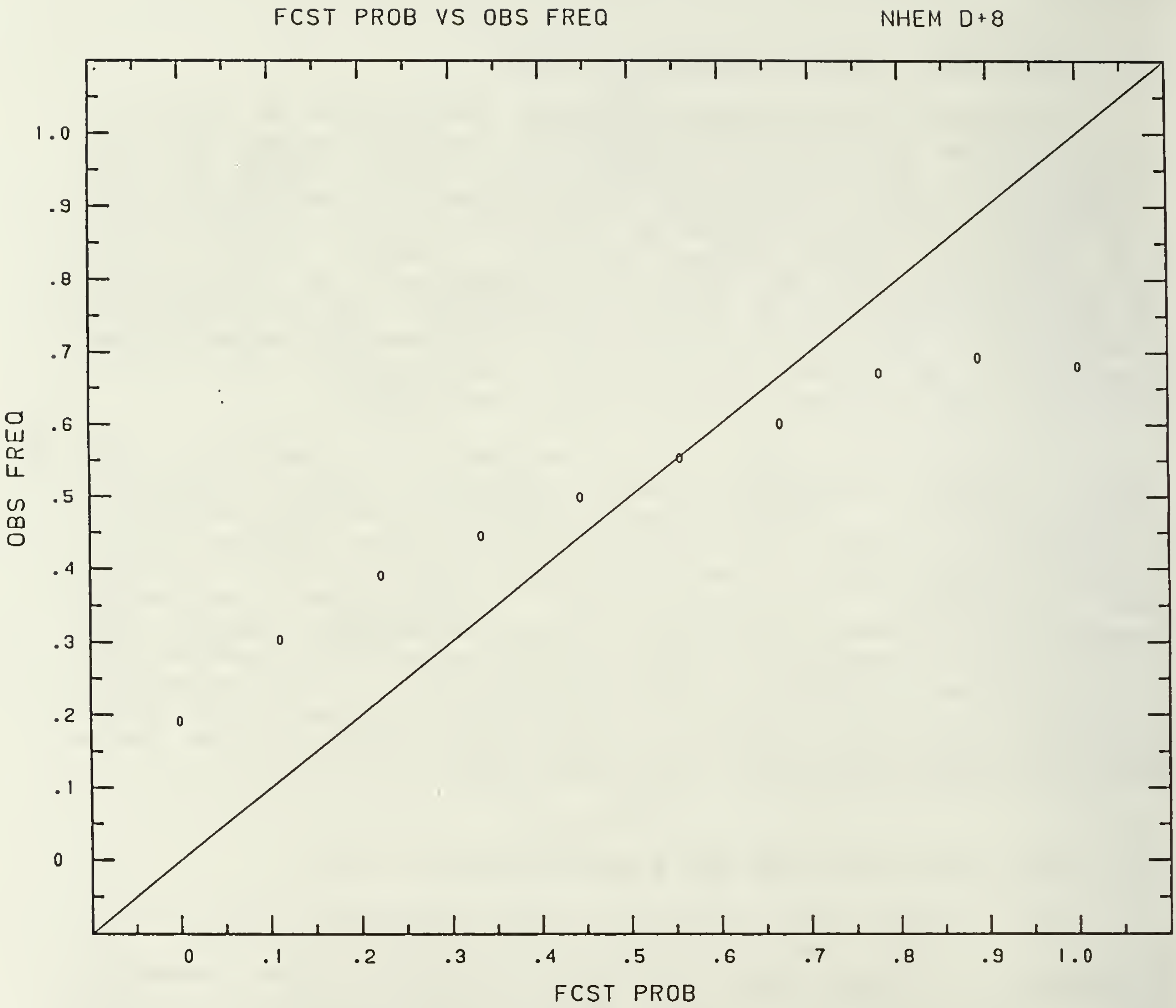

Figure 38: Forecast probability versus observed frequency of positive D+8 500mb height anomalies exceeding 0.5 standard deviations from normal. Plotted values are the means over 34 cases run twice per month from February 1991 through May 1992.

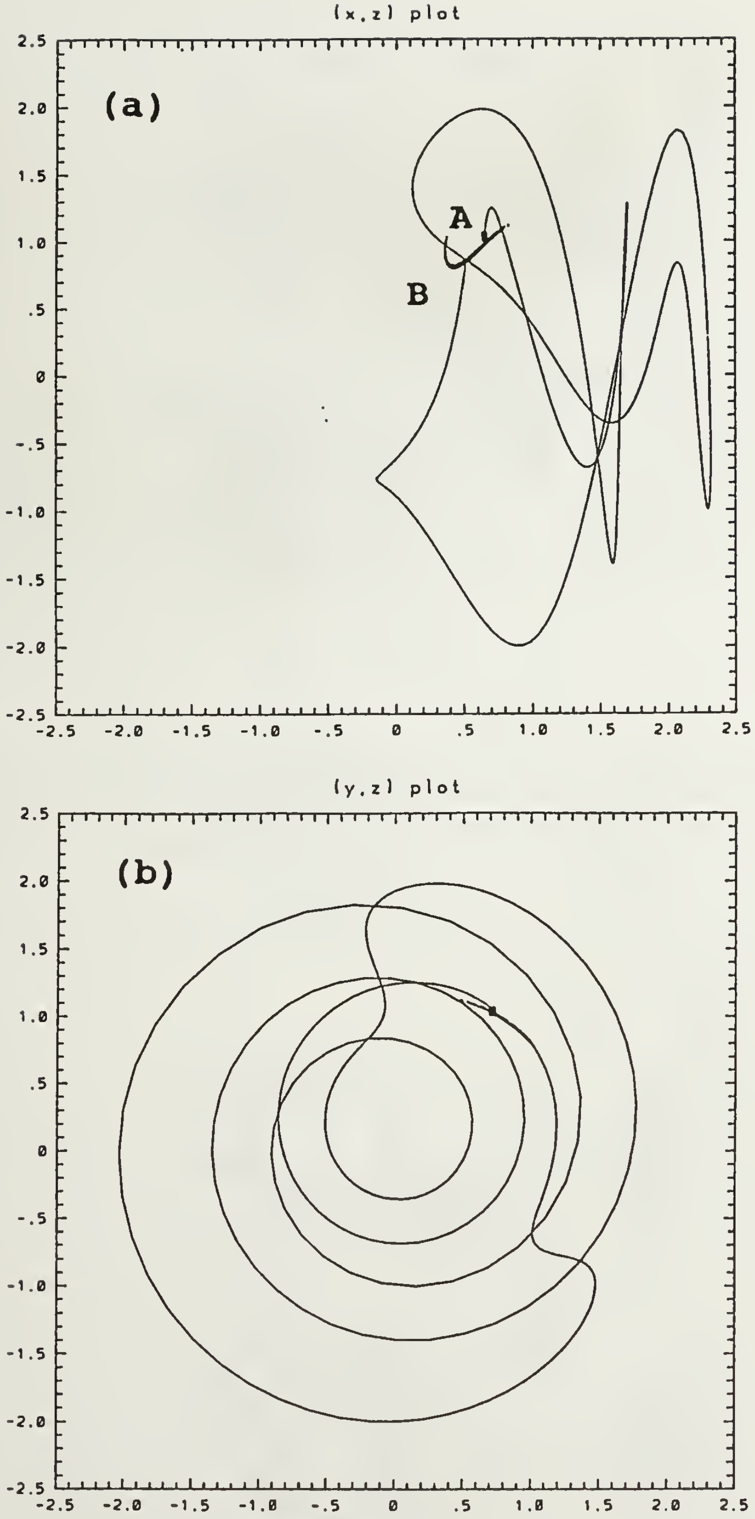

Figure 39: The beginning (denoted as A) and ending (denoted as B) positions of 1000 integrations of 42 - days duration. The solid curve illustrates the intervening trajectories of one of the runs. The results are presented in the XYZ 3D space. The (a) panel shows the view on the X-Z surface and the (b) panel shows the view on the Y-Z surface.

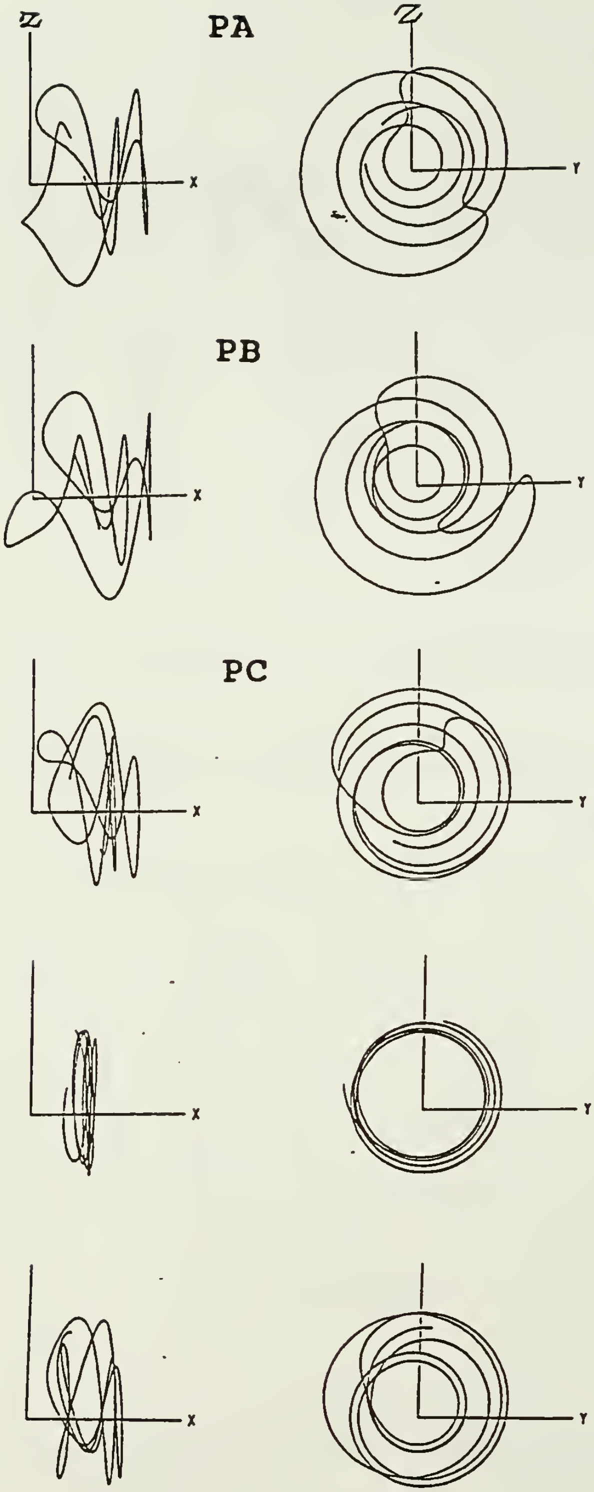

Figure 40: Five consecutive attractor patterns, each of which consists of 42 days of evolutions. The trajectories are presented in the XYZ 3D space. The panels on the left show the projections on the X-Z surface and the panels on the right show the projections on the Y-Z surface.

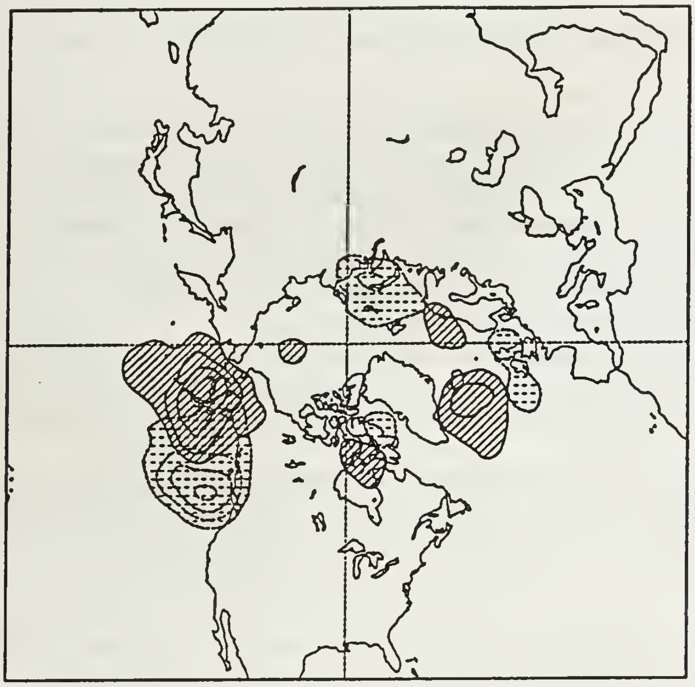

Figure 41: Percentage of time during 755 wintertime days that the observed positive anomaly exceeds 240m (slant-shaded areas), compared to the percentage of time during 1510 wintertime days that the GCM positive anomaly exceeds 180m (horizontally-shaded areas).

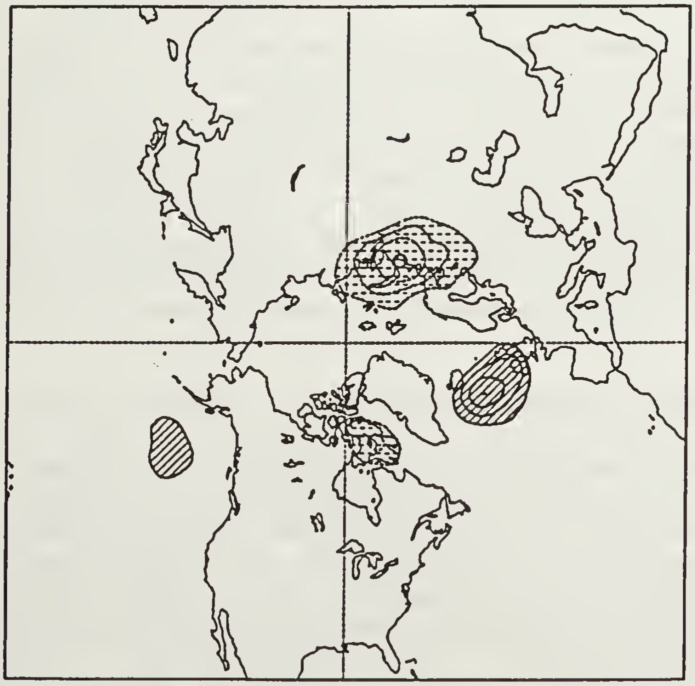

Figure 42: Same as figure 41, except for the superpositioning of the negative anomalies.

7.2.6 Prediction of Persistent Atmosphere States (Anderson)

An examination was made on the ability of the MRF model to generate and to persist blocking events. The DERF90 data set provided MRF (T40) forecasts with leads up to 90 days. A steep decline in the number of model blocks was discovered as lead times increased from 1 to 15 days; however, after 15 days the number of blocks greatly increased. Climate drift in the model apparently prevents formation of blocks during an early transient phase; however, blocks are not precluded from the model once the climate has nearly equilibrated to the model climate. The ability of the operational MRF to produce blocks was also examined for individual months from November 1991 through July 1992. Most months continue to show a sharp decrease in block frequency with lead time; although a few months, in particular February 1992, were found to have an increasing number of blocks with lead time.

7.2.7 A Long Series of Extended Range (90-day) Forecasts (van den Dool)

The goal of this joint project (Saha, Kalnay, Kanamitsu, NMC/Development Division) is to study seasonal forecasts/ simulations using a state-of-the-art general circulation model. The model integrated was a T40 version of the global spectral Medium-Range Forecast (MRF) model used operationally (at T80 resolution) on the CRAY-YMP8 supercomputer at the National Meteorological Center (NMC). This model, which has 18 vertical levels in the sigma coordinate system, was integrated out to 90 days from 128 successive initial states, starting from May 3 to October 6, 1990. First a definition of a "unskillful" set of forecasts was developed, using verification data from years other than 1990. Then, simple statistical techniques were applied to determine the ranges at which skill disappeared in the DERF90 extended-range MRF forecasts. Skill was found to be limited to about 10 days in the Northern Hemisphere and to about 16 days in the Southern Hemisphere.

7.2.8 Simplified Dynamical Models (Anderson, van den Dool)

Several experiments with a barotropic model were performed to examine the possibility that simple, forced models can provide useful predictions at extended ranges. An optimization technique was used to initialize the barotropic model using the first 5 days of a MRF forecast, and then extending the barotropic forecasts out to 10 days. The results were not very promising. In a related task, a code was written for a smart vorticity anomaly advection model that extends the MRF from day 5 onward. This simple model is competitive with the MRF and ECMWF models for the 6 to 10-day range in the cold half of the year.

7.2.9 The Climate in a Multi-Year NMC Model Run (van den Dool, Ebisuzaki)

The purpose of this joint study (Saha, NMC/Development Division) is to establish the climate properties of a state-of-the-art general circulation model. The model is a T40 version of the global spectral Medium-Range Forecast (MRF) model that is used operationally (higher resolution) at NMC. The model has 18 vertical levels in the sigma coordinate system and was integrated for 10 years (3653 days) on the CRAY-YMP8 super computer from initial conditions on July 31, 1991. The lower boundary conditions such as solar radiation, snow depth, soil moisture, sea-ice and sea-surface temperature were updated daily.

In regard to external conditions, 10 identical annual cycles were run and year-to-year variability can therefore be attributed to the model's internal dynamics. Mass was generally well conserved with an increase of only 3 millibars in global mean surface pressure over 10 years. The output was archived at a reduced (T21) resolution and is being used for further diagnostics. Subsequent runs have been performed with interactive soil moisture. In addition, preparations were made for the DOE/Atmospheric Model Intercomparison Project, a 10-year run with observed interannual SST variations.

7.2.10 Systematic Errors in MRF Model Five Day Mean 500mb Height Anomaly Predictions (Schechter)

The purpose of this study is to determine the nature of systematic errors in the MRF model of forecasted five-day mean 500-mb height anomaly centers. The spatial distribution of these anomaly centers is a lag tool used to prepare the 6 to 10 day and 30-day forecasts. So far, forecasts from the MRF model have been examined for the December 1986-November 1987 period, with positive and negative anomaly centers being treated separately. Individual anomaly centers that met specified criteria were tracked during each available MRF model forecast cycle on an interactive computer system.

Verification of anomaly tracks was achieved using 5-day mean 500-mb height analysis, with statistics on the anomaly track errors stratified by month and season. Now that a full year of data is available, efforts are underway to relate the observed systematic track forecast errors to several indices that reflect characteristics of the 500-mb flow regime present in the initial conditions. An effort will also be made to detect any systematic error behavior during blocking episodes.

7.3 Evaluation

7.3.1 Evaluation of Operational Outlooks (Livezey, Hoopingarner)

Efforts continued toward producing detailed documentation of the variability over time by season, location, parameter, and class of the skill of U.S. monthly and seasonal prediction procedures. This information is intended to provide input for management of forecast operations and for the forecasters themselves, as well as for guidance for potential users in deciding whether to include the forecasts as part of their particular decision-making process. Highlights of new results include unambiguous indications that seasonal forecasts of wintertime U.S. temperature and precipitation and summertime temperature forecasts all have skill. However, temperature and precipitation forecasts in the spring have little skill. Weaker, but suggestive, indications imply that some success has been achieved for fall temperature and summer and fall (especially) precipitation predictions. The latter have been particularly skillful in the last decade.

Of particular interest is the contrast in performance of the skillful forecasts mentioned above over the most recent ten years and the same forecasts made during the previous decade and a half. Skill levels of winter precipitation outlooks and summer temperature outlooks have been consistent from period to period and the latter has in fact increased. In sharp contrast is the skill of the set of winter temperature forecasts that has dropped precipitously in the last decade. Analyses have demonstrated that this was principally the result of the failure of the forecast process to account for a strong decadal warm bias in winter temperature. It is interesting to speculate why forecasters were successful in accounting for the same bias in the summertime, a fact that may be related to forecaster preference for forecasts of "least regret", i.e., cold winter forecasts and warm summer forecasts.

7.4 Operational Products

7.4.1 Six to Ten-Day Forecasts (O'Lenic)

This past year was a momentous one for CAC's six to ten-day forecast operation. The Prediction Branch had to respond to an alleged security leak of one its forecasts during summer 1991. The Branch's forecast staff fulfilled all recommendations made by the DOC Inspector General and these changes were in place before the final report appeared. Also, more improvements were made as a result of obtaining new hardware and major benchmarks were achieved in the automation of final map production, message composition, and product transmission.

The forecast operation had a significant loss due to the untimely death of Fran Hughes in February. It is fortunate that his legacy to the Prediction Branch was a set of very robust computer codes and techniques for the 6 to 10-day forecasts. This enabled the operation to continue so that plans for upgrades could be implemented.

In March 1992, the 6 to 10 day temperature skill (five-class) scored an all-time record for any month. In September 1992, the temperature skill scored a record high for that month.

7.4.2 Monthly Outlook (O'Lenic)

The skill (Heidke) of monthly three-class temperature and precipitation forecasts over the U.S. averaged 11.4, for temperature and 7.1 for precipitation. **Figure 43** shows the month-to-month variation in skill. The skill of temperature forecasts was highest during the winter, spring and late summer and lowest in the fall and mid-summer. Skill for precipitation was positive from the October-November forecast through April-May. Such a long run of relatively good precipitation forecasts is quite unusual. Many of these forecasts had precipitation maxima across the south and along the Gulf Coast, which were likely related to the ENSO warm event.

7.4.3 Seasonal Outlook (O'Lenic)

Although the skill of the 90-day temperature forecasts averaged only 2.4 over the last year, precipitation forecasts scored a remarkable **average** value of 13.5. In fact, only two of the 12 seasonal precipitation forecasts made during the period had negative scores, while nine were above a skill of 10 (**fig. 44**). As was the case with the monthly precipitation forecasts, the source of this skill is likely associated with the presence of an ongoing ENSO warm event.

7.4.4 Modernization of Forecast Operations (O'Lenic)

Progress was made in consolidating many upgrades made to the 6 to 10-, 30- and 90-day forecast operations. A PC-486 and a digitizer were obtained for the 6 to 10-day forecast area, which greatly improved control over the security of the operational products. This equipment increased the speed and accuracy that forecasts could be inserted into the computer and also enabled the upgrades and new procedures of the 6 to 10-day operation to be transferred to the 30- and 90-day operations.

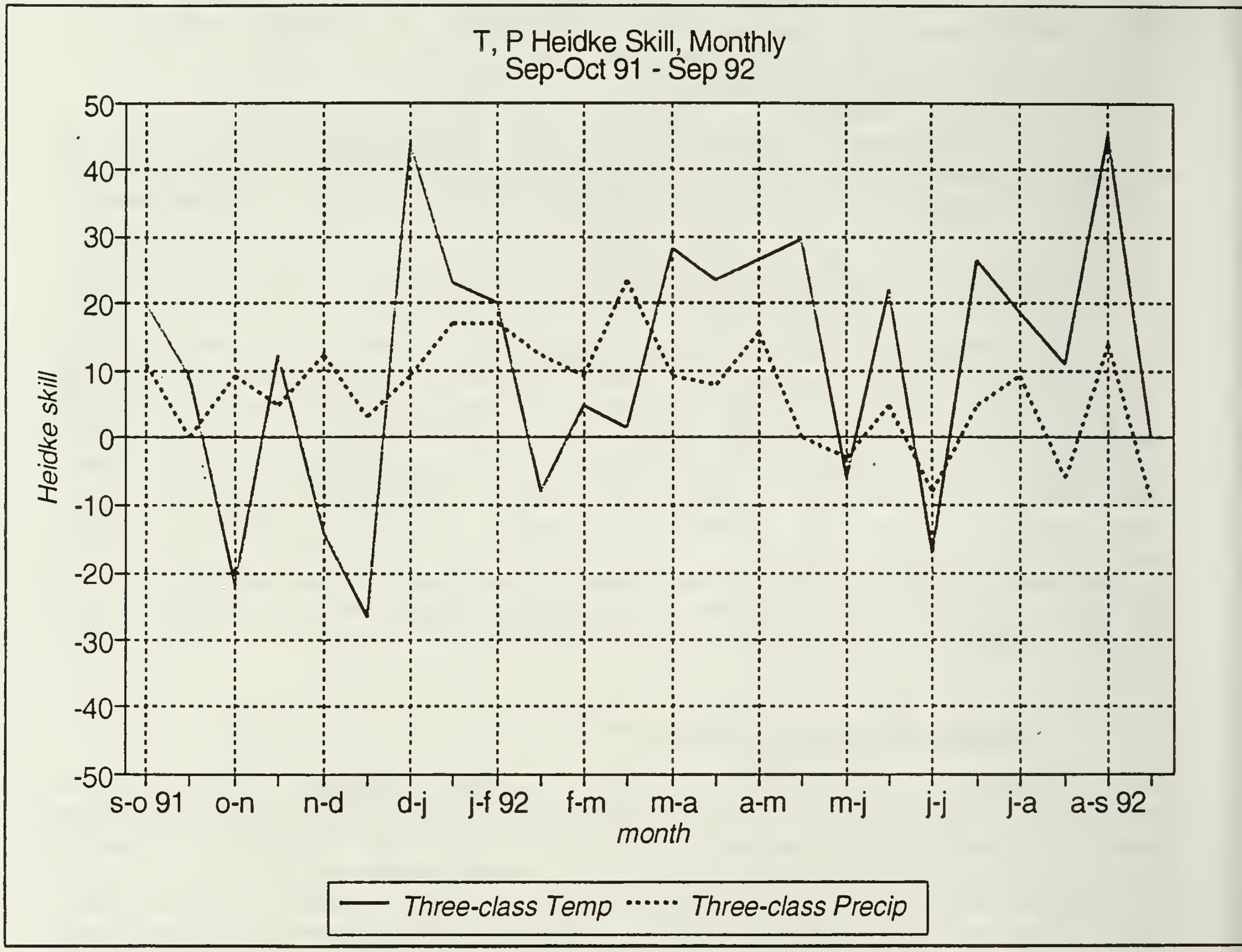

Figure 43: U.S. area average Heidke skill score of 30-day forecasts of monthly mean surface air temperature and precipitation from September - October 1991 through September 1992.

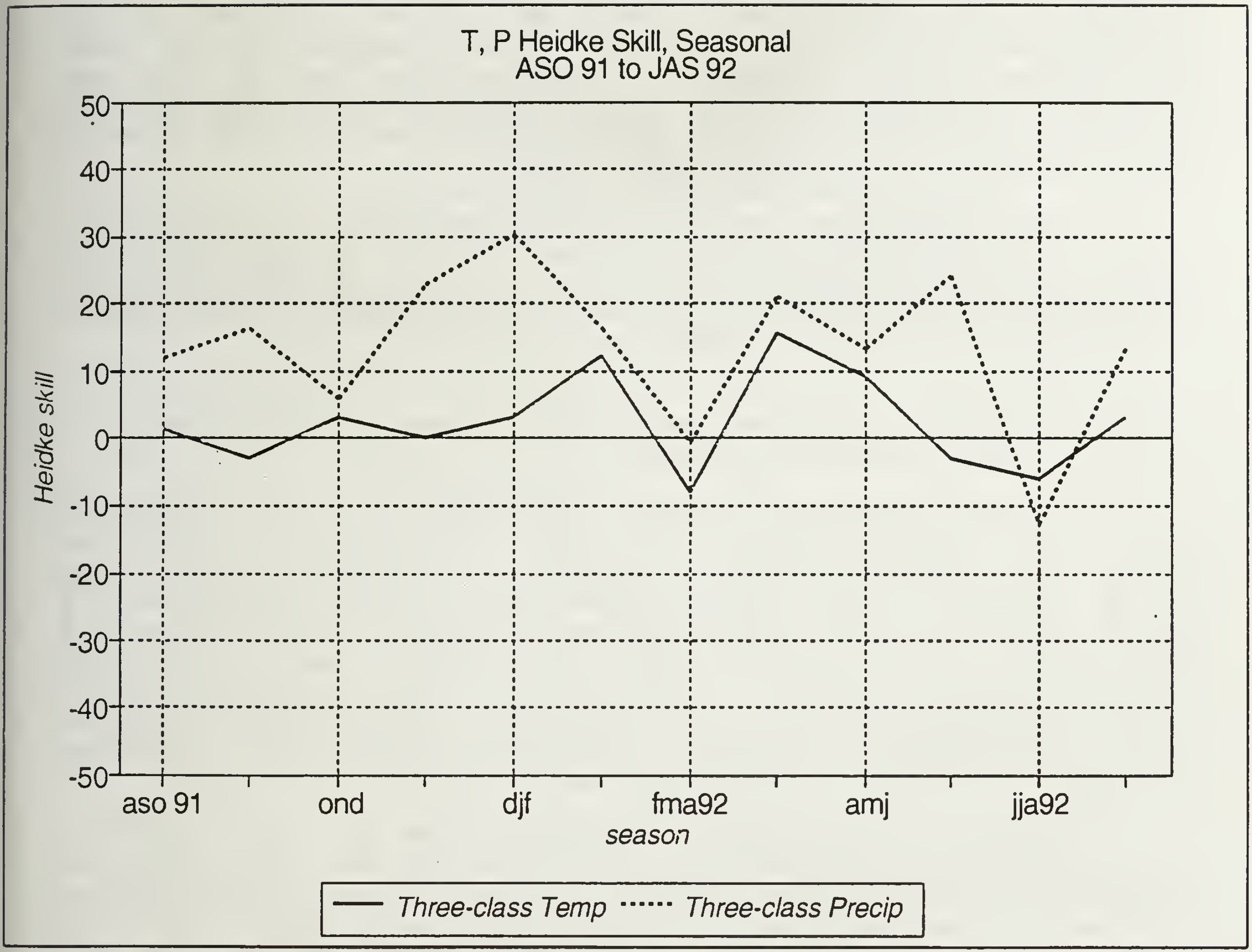

Figure 44: Same as figure 43, but for 90-day forecasts from August-September-October 1991 through July-August- September 1992.

A prime example of this technology transfer is reflected in the upgrade of the Monthly and Seasonal Weather Outlook. Software was generated and new procedures were established that enabled publication-ready graphics to be created on an Intergraph and its text on a PC. These improvements now make the entire process automated, eliminate one day of work per forecast, enable products to be disseminated automatically, and provide the option of making future improvements to the camera-ready product with relative ease.

The Prediction Branch has embarked upon a joint effort with the NMC/Workstation Committee. This is an opportunity to demonstrate the effectiveness of using SGI workstations and centralized coordination, planning and management of workstation activities in a forecast operation.

7.4.5 A Circulation-Based Check on U.S. Temperature Trends

(van den Dool, O'Lenic)

A perfect prog technique for computing surface temperatures from observed monthly mean 700mb height anomalies (derived by W. Klein) has been used as a 30-day forecast tool for many years. Recently, this product has produced temperatures with a quite noticeable cold bias over much of the United States, as was noted in 1991. Surface temperatures being warmer than those specified by concurrent 700-mb flow would be consistent with a number of causes (physical/measurement). These include: biased (high) thermometer readings, increased urbanization, increased drought, decrease in snow cover, and increased trace gases.

Figure 45 provides an update through the end of 1991. The plotted curve shows the difference between specified and observed surface temperatures for 109 U.S. stations. Each series has been subjected to a 13-month running mean. Although the warm trend continued through the 1991-92 winter, it was followed by a tendency toward abnormal coolness during Spring and Summer. The cause, if any, in the **warming** trend has not yet been identified. The wide-spread cloud of sulfuric acid droplets, due to the eruption of Mt. Pinatubo, has been suggested as a possible reason for the more recent cooling.

7.5 Supporting Projects

7.5.1 Anomaly History and Teleconnections (Wagner)

Monthly and seasonal mean temperature and precipitation charts for the late 19th and early 20th centuries have now been produced for all months except November through February, and for all seasons except for November-January through February-March. These maps, based on the CAMS data set (produced by CAC), are now available to aid monthly and seasonal forecasters in the selection of specification analogs.

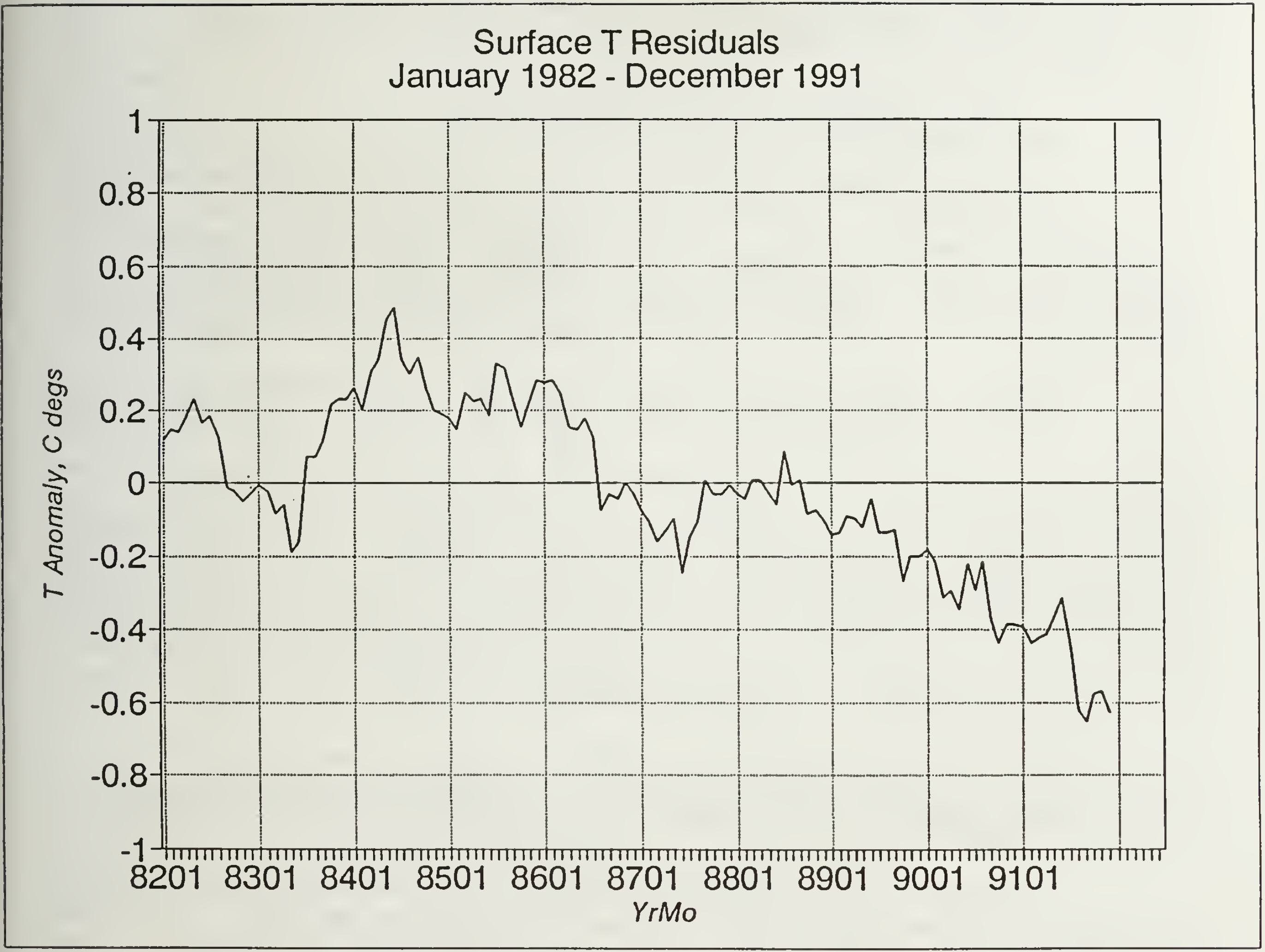

Figure 45: Arithmetic difference, or residual (S-O) between U.S. area-averaged surface temperature specified from observed monthly mean 700mb height (S) and observed monthly mean surface air temperature (O) from 1982 through 1991.

Hard-copy teleconnection maps have now been produced for most of the remaining latitude/longitude grid points in the vicinity of North America for all months of the year. These maps are used by the 6 to 10- day and 30-day forecasters in evaluating the internal consistency of mean height prog maps produced by different models. These charts are also used to fill in areas where the height-anomaly prognostic charts from the models are considered highly uncertain or unreliable.

7.5.2 Long-Lead Seasonal Forecasts (Wagner)

The Heidke skill scores for the 11th year of **experimental** long-lead seasonal forecasts were substantially positive. These included: Summer 1991 at all ranges; Fall 1991, except raw temperature persistence for two-, three-, and four-season lags; Winter 1991-92, except for two- and three-season lags; and Spring 1992, only at the longest range of two years ahead.

Skill scores, averaged over the entire 11-year period of quasi-real-time forecasting (i.e., truly independent data), are significantly positive at all ranges in summer except for two-year persistence, when compared with Monte Carlo distributions derived from past observed data for each season. There is significant skill for forecasts made at two- and three-season lags in fall; no significant skill at any range for winter, and very high significant skill at all ranges, except for two-season persistence in spring. It is believed that the unusually high skill scores displayed by the spring forecasts are due largely to the pronounced warming trend evidenced for that season during the 1980's.

7.5.3 NWS Forecasting Handbook and Operations Manual Revision (Wagner)

A revision and update were made to the descriptive text accompanying the manual and automated graphics of AFOS products that are generated by CAC. This material was submitted to the User Services Branch of the NWS/Office of Meteorology for incorporation into the new Forecasting Handbook. The chapter in the Operations Manual that contains CAC's 6-10, 30- and 90-day forecast graphics and messages was also updated and sent to the Warning and Forecast Branch of the NWS/Office of Meteorology. In addition, the headers on all of the forecast descriptive messages and prognostic map discussions were rewritten in a standard format.

8. SUMMARIES

8.1 Climate and Global Change Program (Rodenhuis, Ropelewski, van den Dool, Livezey, Mo, Janowiak, Miller)

The primary focus of Climate and Global Change activities at the CAC is on climate diagnostics, climate monitoring, and climate trends. The accomplishments for related tasks are described in preceding sections of this report. They include: Sections 1.2.1.2, 1.2.3, 1.2.4, 1.2.5, 1.3.1; 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.4, 2.3.2.1, 2.3.2.2, 2.4.3; 6.2.1, 6.2.2, 6.3.4; 7.1.2, 7.2.1, and 7.2.2.

CAC is a participant in a number of FY 1992 Tier I Projects under the NOAA Climate and Global Change Program. These include: Stratospheric Monitoring and Data Management (with ERL), Vegetation Index (with NESDIS), Climate Data Assimilation System (with NMC), Global Climate Perspectives (with NESDIS), Global Precipitation Climatology Project (with WMO/WCRP), and DERF (with ERL, GFDL, and NMC).

In addition to the above Projects, CAC staff have either originated or collaborated in new proposals that were submitted to the Office of Climate and Global Change for FY 1992 funding. These include: North American Land Surface/Atmospheric Hydrologic Cycle, and Soil Moisture and Temperature Predictions Over the United States.

8.2 TOGA Activities (Diagnostics Branch Staff)

The primary focus of TOGA activities at the CAC is on operational monitoring of the ENSO and oceanic-atmospheric fluctuations. The accomplishments for related tasks are described in preceding sections of this report. They include: Sections 1.1.2, 1.2.1.1; 2.3.1, and 2.4.1.

8.3 EPOCS Activities (Diagnostics Branch staff)

The primary focus of EPOCS activities at the CAC is on diagnostic studies of the oceanic-atmospheric circulation in the tropics. The accomplishments for related tasks are described in preceding sections of this report. They include: Sections 1.1.1 and 1.1.4.

Proposals that were approved by the EPOCS Program Office for support in FY 1992 included: "Diagnostics Studies of the Coupled Ocean-Atmosphere System," (Ropelewski, Chelliah and Smith - P.I.'s) and "Planetary-scale Monsoon Circulation and ENSO Cycle," (Rasmusson and Mo - P.I's).

8.4 Bilateral Activities

8.4.1 U.S.-Brazil Bilateral Agreement (Kousky)

Under the auspices of the U.S. - Brazil Bilateral Agreement for Science and Technology, Mr. J. C. Figueiredo, from the Institute of Meteorological Research in Brazil, Mr. C. Repelli, from the Ceara Foundation for Meteorology and Hydrological Resources in Brazil, and Capt. Aloar, from the Naval Department of Hydrography, Brazil completed visits to the South American Desk. Visiting Scientists to the South American Desk participate in the preparation of numerical forecast discussions, which are disseminated on the Global Telecommunications System (GTS) to all South American countries, and in forecast evaluation studies.

At the beginning of each month a description is prepared (by Kousky and Bell) concerning the current climate anomalies in the tropical Pacific and disseminated via the GTS to South American countries.

8.4.2 U.S.-Russian Bilateral Agreement (Rodenhuis, Ropelewski)

Under the activities of the U. S./Russian Bilateral Agreement: Working Group VIII, D. Rodenhuis attended an informal Workshop on Hydrology in St. Petersburg, Russia in October 1991. He used this opportunity to discuss climate assessment, data rescue and new proposals. Subsequently, a proposal was received in March 1992 from Professor Budyko.

A return visit by G. Menzhulin was made in January 1992 to present lectures and transfer agroclimatic data to USDA, USGS and NOAA. He also visited Columbia University to collaborate on a joint project.

A new proposal on data access and rescue was written with collaborators from NOAA, USGS and NCAR. A number of projects were planned, but participation was not possible at the Annual Climate Diagnostics Workshop, Annual Meeting of Working Group VIII, and Scientific Exchange on Teleconnections.

8.5 World Climate Program Activities

8.5.1 Climate System Monitoring (Ropelewski, Rodenhuis, Kousky)

The CAC provided data, graphics and analysis support for the WMO's Climate System Monitoring (CSM) Bulletins and Biennial Review. The Fourth CSM Review, which contains several analyses from the Climate Analysis Center, was drafted and distributed.

CAC staff participated in the planning activities of the WMO Climate Change Detection Project. Among these were meetings in Geneva, Switzerland (October 21-23, 1991) and at the Fourth International Meeting on Statistical Climatology in Toronto (June 23, 1992). Ropelewski served as Chair of the Working Group on Statistical Detection of Climate Change at the Geneva meeting.

8.5.2 Global Precipitation Climatology Project (Janowiak)

The CAC is the main center for producing pentad and monthly rainfall analyses from satellite infrared data over the global tropics for the WMO/ICSU administered Global Precipitation Climatology Project (GPCP). Several NOAA-wide workshops and formal scientific meetings were attended during the year in which GPCP activities were discussed. An international meeting on precipitation analysis in Koblenz, Germany was attended (by Janowiak) in September, 1992. In addition, several smaller scale meetings among NMC and NESDIS scientists were held in which GPCP products and plans were of general interest.

8.5.3 Global Energy Water Cycle Experiment (GEWEX) (Ropelewski)

CAC staff (Ropelewski) served as a member of the GEWEX Continental International Project (GCIP) Date Management Committee (DACOM). Ropelewski also chaired the Working Group on Surface Observations at the GCIP Data Management Workshop in Saskatoon, Saskatchewan (May 4-8, 1992). CAC co-hosted, with NESDIS, a DACOM Working Group Meeting on September 24, 1992.

8.5.4 Intergovernmental Panel for Climate Change (IPCC) (Ropelewski, Chelliah)

CAC provided a number of parameters as input to the IPCC update report. These include: outgoing longwave radiation data, and uncertainties in global sea-surface temperature, sea-ice and snow-cover estimates.

8.5.5 Commission on Climatology (CCl) (Rodenhuis, Ropelewski)

An international Working Group Meeting was held in Geneva, Switzerland in October 1991. Plans were discussed in regard to the development of a WMO/Climate Change Detection Program.

8.6 National Weather Service Programs

8.6.1 ASOS Climate Working Group (Rodenhuis, Ropelewski)

A Climate Working Group (CWG) Meeting, held at NWS Test Facility, Sterling, VA (May 1992), resulted in 15 individual areas of concern or recommendations under 6 major topic headings. These were passed along to the ASOS Steering Group for comment and action. The major result has been the establishment of a plan for an intercomparison of ASOS and "conventional" instrumentation at several climatologically-representative sites.

8.7 Annual Climate Diagnostics Workshop

8.7.1 Sixteenth Annual Climate Diagnostics Workshop (Rodenhuis, Mo)

The NMC/Climate Analysis Center and UCLA/ Dept. of Meteorology were co-sponsors of the Sixteenth Annual Climate Diagnostics Workshop, held in Lake Arrowhead, CA (October 28-November 1, 1991). These Workshops provide a forum for researchers to present recent results and to exchange ideas on a variety of climate topics. This meeting focused on: ENSO; Low-Frequency Variability; Stratosphere; Ocean Circulations; Ocean-Atmosphere Interactions; Contemporary Climate Issues; Global Climate Change; Hydrology and Precipitation; ENSO and Seasonal Forecasts; and Climate Prediction. There were 85 presentations; a Proceedings was published and distributed in March 1992.

8.7.2 Seventeenth Annual Climate Diagnostics Workshop (Rodenhuis, Halpert)

Preparations were made for the 17th Annual Climate Diagnostics Workshop to be held at the University of Oklahoma in Norman, OK, (October 19-23, 1992). Dr. Peter Lamb is leading the organizing efforts at the University for the Workshop. The co-hosts include: the School of Meteorology, the National Severe Storms Laboratory, the Oklahoma Climatological Survey, and the Cooperative Institute of Mesoscale Meteorological Studies. The Workshop will focus on the following topics: Recent Climate Anomalies; ENSO; Air-Sea Interaction, Regional Climate Studies, Hydrology/Precipitation, Climate Data Sets/ Remotely-Sensed Data, Model Studies, Low-Frequency Variability, Intraseasonal/Interannual Variability, Statistical Climatology, and Climate Prediction.

9. BIBLIOGRAPHY

9.1 Journal Articles

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Tracton, M. S., "The practice and problems of operational medium-range forecasting at the National Meteorological Center, Washington, DC," Proceedings of the ECMWF Third Workshop on Meteorological Operational Systems, Reading, U.K., Nov. 18-22, 1991, pp. 29-37.

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van den Dool, H. M., S. Saha and Z. Toth, "The climate in a multi - year NMC model run," Proceedings of the AMS/Fifth Conference on Climate Variations, Denver, CO, Oct. 14-18, 1991, pp. 511-514.

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Wang, X-L. and K. C. Mo, "Australian summer monsoon and its association with cold surges and intraseasonal oscillation," Proceedings of the AMS/Fifth Conference on Climate Variations, Denver, CO, Oct. 14-18, 1991, pp. 335-337.

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9.3 Presentations at Formal Scientific Meetings *

Basist, A., "Research comparing the mean tropospheric temperatures derived from NMC analyses and channel 2 of the NOAA Microwave Sounding Unit," presented at NASA/Marshall Space Flight Center, Huntsville, AL, August 11, 1992.

Basist, A. N., "Global temperatures using satellite and numerical model assimilated data," presented at the Space Congress: COSPAR, Washington, D.C., September 3, 1992.

Gelman, M. E., "UARS data and the NOAA Stratospheric Program," presented at the Eight Conference on the Middle Atmosphere, Atlanta, GA, January 5-10, 1992.

Gelman, M. E., "Use of UARS data in the NOAA Stratospheric Monitoring Program," presented at the 29th COSPAR Meeting, Washington, D.C., August 28-Sept. 5, 1992.

Janowiak, J. E., "Status of the CAC Precipitation Data Center," presented at the 6th JSC Working Group on Data Management of the GPCP, Asheville, NC, August 5, 1992.

Janowiak, J. E., "Rainfall estimates from IR imagery," presented at the International Workshop on Analysis Methods of Precipitation on a Global Scale, Koblenz, Germany, September 15, 1992.

Kousky, V. E., "Atmospheric/oceanic circulation changes related to extremes in the Southern Oscillation," presented at the PACLIM Meeting, Pacific Grove, CA, April 21-24, 1992.

Kousky, V. E., "Observation and empirical studies on interannual variability," presented at the First NOAA Colloquium on Environmental Prediction, NOAA Science Center, Camp Springs, MD, June 2, 1992.

Kousky, V. E., "Seasonal to interannual variations in atmospheric circulation and precipitation over tropical South America," presented at a Workshop on ENSO and Seasonal to Interannual Climate Variability: Socioeconomic Impacts, Forecasting, and Applications to the Decision-Making Process, Fortaleza, Brazil, September 10, 1992.

Laver, J. D., "The CAC Dial-Up Service and networking capabilities as they relate to improving climate system monitoring," presented at the WMO/CCl Experts Meeting on Tracking and Transmission of Climate System Monitoring Information, Geneva, Switzerland, November 7-8, 1991.

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* (There were 46 additional formal presentations that were also published; but, these are listed only in Section 9.2.)

Laver, J. D., "Collection, dissemination and quality control of CLIMAT and SYNOP data at the Climate Analysis Center," presented at the WMO/CCl Working Group on Climate Data, Geneva, Switzerland, November 11-15, 1991.

Laver, J. D., "Update on Climate Analysis Center operational and research activities, and interactions with state climatologists," presented at the Meeting of the American Association of State Climatologists, Bowling Green, KY, August 8, 1992.

Le Comte, D. M., "The NOAA/NESDIS Impact Assessment Project for drought early warning in the Sahel," presented at CODATA Commission on Global Change Data International Workshop on Integration, Dissemination and Use of Environmental Data for Research and Crop Modeling, Chambery, France, March 2-5, 1992.

Lehman, R. L., "Evaluating extremes in climatological time series," (guest lecture), presented at the Washington Statistical Society, Washington, D.C., January 17, 1992.

Miller, A. J., "Comparison of NOAA/NMC stratospheric wind analyses with UARS High Resolution Doppler Imager (HRDI) wind measurements," presented at the Quadrennial Ozone Symposium, University of Virginia, Charlottesville, VA, June 4-13, 1992.

Miller, A. J., "Ozone determinations with the NOAA SBUV/2 System," presented at the Quadrennial Ozone Synmposium, Charlottesville, VA, June 4-13, 1992.

Mo, K. C., "MONEG experiments using the NMC MRF model," presented at the TOGA/MONEG Workshop, Boulder, CO, October 21-23, 1991.

Mo, K. C., "Atmospheric water vapor transport over North America during the summers of 1988 and 1991," presented at the Annual AGU Meeting, San Francisco, CA, December 8-12, 1991.

Mo, K. C., "Ozone and stratospheric height waves during 1986-1990," presented at the Quadrennial Ozone Symposium at the University of Virginia, Charlottesville, VA, June 4-13, 1992.

Nagatani, R. M., "Temperatures, net radiative heating and residual circulation," presented at the Workshop on Stratospheric Models and Measurements 1992: A Critical Comparison, Satellite Beach, FL, February 2-7, 1992.

Nagatani, R. M., "The 27-day solar UV response of stratospheric ozone: Solar cycle 21 versus solar cycle 22," presented at the International Symposium on the Middle Atmospheric Sciences, Kyoto, Japan, March 23-27 1992.

Nagatani, R. M., "A comparison of NOAA SBUV/2 ozone data with MLS measurements from UARS," presented at the Quadrennial Ozone Symposium, Charlottesville, VA, June 4-13, 1992.

O'Lenic, E. A., "Six-to-ten, thirty-, and ninety-day forecasting at NMC," presented at the NOAA Colloquim on Operational Environmental Prediction, NOAA Science Center, Camp Springs, MD, June 1-26, 1992.

Ropelewski, C. F., "Operational monitoring and empirical predictions of ENSO," presented at the Annual AGU Meeting, San Francisco, CA, December 9-13, 1991.

Ropelewski, C. F., "CAC operational snow cover monitoring," presented at the Global Climate Perspectives System Workshop, Camp Springs, MD, March 12-13, 1992.

Ropelewski, C. F., "NMC data bases for GCIP research," presented at the GCIP/Date Management Workshop, Saskatoon, Saskatchewan, Canada, May 5, 1992.

Ropelewski, C. F. "Weather anomalies associated with ENSO events," presented at the Workshop on The Economic Impact of ENSO Forecasts of American, Australian and Asian Continents, Florida State University, Tallahassee FL, August 11-13, 1992.

Ropelewski, C. F. "Precipitation and temperature patterns associated with the Southern Oscillation," presented at a Workshop on ENSO and Seasonal to Interannual Climate Variability: Socioeconomic Impacts, Forecasting, and Applications to the Decision-Making Process, Fortaleza, Brazil, September 15, 1992.

Schultz, P. A., "Global correlation of temperature, NDVI and precipitation," presented at the World Space Congress: COSPAR, Washington, D.C., September 5, 1992.

Tinker, R. J., Data management at the Climate Analysis Center: Current activities and year 2000 requirements," presented at the ESDIM Meeting, Boulder, CO, May 25-29, 1992.

Tracton, M. S., "Summary of DERF research," presented at the DERF Project Scientific Advisory Panel Meeting, Estes Park, CO, October 9-11, 1991.

Tracton, M. S., "Prospects for long-range numerical weather prediction," presented at the Ninth AMS Conference on Numerical Weather Prediction, Denver, CO, October 14-18, 1991.

Tracton, M. S., "The practice and problems of operational medium-range forecasting at the National Meteorological Center, Washington, D.C.," presented at the ECMWF Third Workshop on Meteorological Operational Systems, Reading, U.K., November 18-22, 1991.

Tracton, M. S., " Dynamical Extended-Range Forecasting (DERF)," presented at the NOAA Colloquim on Operational Environmental Prediction, NOAA Science Center, Camp Springs, MD, June 1-26, 1992.

van den Dool, H. M., "A 10-year run with NMC’s global model," presented at the DERF Advisory Panel Meeting, Estes Park, CO, October 10, 1991.

van den Dool, H. M., "Forecasting forecast skill, probability forecasting, and the plausibility of model produced flow," presented at the ECMWF Workshop on Predictability, Reading, UK, November 14, 1991.

Yang, S-K., "Recent changes on NMC’s forecast system," presented at the 6th CERES Science Team Meeting at NASA Langley Research Center, Hampton, VA, October 30-31, 1991.

Yang, S-K., "A comparison of longwave cooling rates from two radiative transfer codes," presented at the 6th CERES Science Team Meeting at NASA Langley Research Center, Hampton, VA, October 30-31, 1991.

Yang, S-K., "Validation of clouds simulated by an experimental mesoscale spectral model at NMC for TAMEX IOP-11," presented at the 11th Conference on Clouds And Precipitation, Montreal Canada, August 17-21, 1992.

9.4 Seminars and Briefings

Anderson, J. L., "The climatology of blocking in a numerical forecast model" presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, March 12, 1992.

Barnston, A.G., "Long-lead statistical predictability in the Northern Hemisphere," presented presented at CAC/ "Horizon" Seminar, NOAA Science Center, Camp Springs, MD, July 7, 1992.

Barnston, A. G., "Statistical predictions in the Northern Hemisphere," presented at the Climate Analysis Center Seminar Series, NOAA Science Center, Camp Springs, MD, Sept. 29, 1992.

Basist, A., "A comparison between satellite microwave and GDAS tropospheric temperatures (1979-1990)," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, June 18, 1992.

Bermowitz, R. J.,"Recent RCC activities," presented at the Annual Meeting of the Southeast Regional Climate Center Board of Advisors, Huntsville, AL, Oct. 10, 1991.

Bermowitz, R. J.,"CAC management of the Regional Climate Center Program," presented at the Midwestern Climate Center Advisory Panel Meeting, Champaign, IL, Nov. 6, 1991.

Bermowitz, R. J.,"An overview of the RCC Program," presented at the NWS Eastern Region Area Managers Conference, Sterling, VA, Jan. 28, 1992.

Bermowitz, R. J., "CAC goals for the Southeast Regional Climate Center," presented at the Southeast Regional Climate Center Site Review, Columbia, SC, July 28, 1992.

Chelliah, M., "Equatorial Pacific sea surface temperatures and ENSO," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Feb. 6, 1992.

Chelliah, M., "Variability in Equatorial Pacific sea surface temperatures on interannual time scales and ENSO," presented at NOAA/GFDL, Princeton, NJ, May 8, 1992.

Chen, W., "Large-scale, low-frequency anomalies of a Comprehensive general circulation model," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Apr. 9, 1992.

Ebisuzaki, W., "A modified lagged-average forecast ensemble," presented before DERF Project Scientific Advisory Panel, Estes Park, CO, Oct. 9, 1991.

Ebisuzaki, W., "Some results from a 5-year run," presented at CAC/ "Horizon" Seminar, NOAA Science Center, Camp Springs, MD, Mar. 10, 1992.

Ebisuzaki, W., "AMIP," presented at CAC / "Horizon" Seminar, NOAA Science Center, Camp Springs, MD, May 5, 1992.

Epstein, E. S., "Prediction, specification, and the Kalman filter," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, May 26, 1992.

Halpert, M. S., "Biases between CLIMAT and GTS-derived temperature and precipitation," presented at the Global Climate Perspectives System Workshop, NOAA Science Center, Camp Springs, MD, Mar. 12-13, 1992.

Huang, J., "Monthly precipitation-temperature relations and temperature prediction over the United States," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, May 21, 1992.

Janowiak, J. E., Rainfall study," presented at NESDIS R&D Council Meeting, NOAA Science Center, Camp Springs, MD, Dec. 17, 1991.

Janowiak, J. E., "Diurnal variation in tropical convection," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Feb. 25, 1992.

Janowiak, J. E., "Unrealistically high rainfall estimates from NOAA-11 histogram data," presented at the NESDIS Product Oversight Panel Meeting, Suitland, MD, June 16, 1992.

Janowiak, J. E., "The Precipitation Anomaly Classification," presented at the CAC Soil Moisture Workshop, NOAA Science Center, Camp Springs, MD, July 10, 1992.

Janowiak, J. E., "GCIP Data Sets at the Climate Analysis Center," presented at the GCIP/DACOM Meeting, NOAA Science Center, Camp Springs, MD, Sept. 24, 1992.

Kousky, V. E., "Update on the Southern Oscillation," presented at UCLA, Lake Arrowhead, CA, Oct. 29, 1991.

Kousky, V. E. "Atmospheric and oceanic anomalies and their effects on precipitation over Brazil" presented at: the Brazil Secretary for Science and Technology, Dec. 4, 1991; the University of Sao Paulo, Dec. 5, 1991; the Sao Paulo Secretary for Science and Technology, Sao Paulo, Brazil, Dec. 5, 1991.

Kousky, V. E., "El Niño and its effects on global atmospheric circulation," briefings at NMC/Meteorological Operations Division, NOAA Science Center, Camp Springs, MD, Jan. 22, 24, and Feb. 6, 1992.

Kousky, V. E., "ENSO," presented before the Subcommittee on Atmospheric Research, National Science Foundation, Washington, D.C., Feb. 27, 1992; and at the NOAA/Oceanic and Atmospheric Management Advisory Committee Meeting, Washington, D.C., Mar. 6, 1992.

Kousky, V. E., "Interannual variations in atmospheric circulation and precipitation associated with the El Niño/ Southern Oscillation phenomenon", presented at the Federal University of Pelotas, Pelotas, Brazil, Sept. 18, 1992.

LeComte, D. M., " The 1991-92 drought in Southern Africa," presented at the Congressional Research Service Discussion on Drought and Famine in Africa, Washington, D.C., Apr. 28, 1992.

Long, C. S., "Updated findings from NOAA/AVHRR satellite remote sensing" presented at Interagency Meeting on Pinatubo Research, Arlington, VA, June 24, 1992.

Mo, K., "Linkages between tropical and extratropical circulation anomalies," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Jan. 16, 1992.

Murphy, A. H., "On the quality of CAC's monthly and seasonal forecasts," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Nov. 7, 1991.

Murphy, A. H., "Economically optimum use of meteorological information, Part II: The continuous case," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Aug. 31, 1992.

Rodenhuis, D. R., "Short-term climate monitoring and prediction," presented at George Mason University, Fairfax, VA, April 14, 1992.

Rodenhuis, D. R., "The sky is falling: A review of global change issues," presented before the Maryland Citizen Action Coalition, Silver Spring, MD, June 4, 1992.

Ropelewski, C.F., "Status of the 1991-92 ENSO," presented to the TOGA Advisory Panel, Miami, FL, Jan. 23, 1992.

Ropelewski, C.F., "CAC historical snow cover data set," presented to the NESDIS Surface Land Products Advisory Committee, NOAA Science Center, Camp Springs, MD, Feb. 2, 1992.

Ropelewski, C. F., "Satellite surface products for climate research and monitoring," presented at NESDIS R&D Counsel Meeting, NOAA Science Center, Camp Springs, MD, Mar. 10, 1992.

Ropelewski, C. F., "The evolution of the 1991-92 El Niño/ Southern Oscillation or What is ENSO and why should you care?," presented at the University of Oklahoma School of Meteorology Seminar Series, Norman , OK, May 21, 1992.

Ropelewski, C. F., "An overview of the WMO Climate Change Detection Project," presented at the DOE Climate Change Detection Project Scientific Steering Committee Meeting, Boulder, CO, June 1, 1992.

Ropelewski, C. F., "The current status of ENSO," presented at the TOGA Panel Meeting, Washington, D.C., June 18, 1992.

Ropelewski, C. F., "Tropospheric biennial variability and ENSO," presented at the Dept. of Meteorology, Florida State University, Talahassee, FL, August 13, 1992.

Smith, T. M., "Spatial correlations for SST and improved error statistics for SST OI," presented at CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Mar. 24, 1992.

Tracton, M. S.,"The practice and problems of operational medium-range forecasting at the National Meteorological Center," presented at NMC Seminar, NOAA Science Center, Camp Springs, MD, Dec. 3, 1991

Tracton, M. S., "MRF skill," presented at NMC/Development Division, NOAA Science Center, Camp Springs, MD, Oct. 15, and Nov. 13, 1991.

Tracton, M. S., "An overview of the highlights of the ECMWF Workshops," presented at CAC's "Horizon" Seminar, NOAA Science Center, Camp Springs, MD, Nov. 20, 1991.

van den Dool, H. M., "Low-frequency waves and traveling storm tracks," presented at CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Oct. 3, 1991.

van den Dool, H. M., "The feasibility of DERF beyond 30 days," presented at a panel discussion in a joint session of 3 AMS Meetings, Denver, CO, Oct. 16, 1991.

van den Dool, H. M., "Long-range forecasting at CAC," presented at the local chapter of AMS, Riverside, CA, Oct. 30, 1991.

van den Dool, H. M., "Een 10-jaar integratie van het operationele NMC-NWP model," presented at the KNMI, DeBilt, The Netherlands, Nov. 18, 1991.

van den Dool, H. M., "DERF," presented at Global Change Review Meeting, NOAA Science Center, Camp Springs, MD, Jan. 24, 1992.

van den Dool, H. M., "Overview of Prediction Branch products developed for enhancing ensemble output," presented at CAC/ "Horizon" Seminar, NOAA Science Center, Camp Springs, MD, Feb. 13, 1992.

van den Dool, H. M., "Progress in the NMC AMIP run," presented at AMIP meeting, Berkeley, CA, Feb. 20, 1992.

van den Dool, H. M., "Medium-range forecast skill," presented at NMC/Development Division, NOAA Science Center, Camp Springs, MD, Jan. 8, Feb. 5, and Mar. 4, 1992.

van den Dool, H.M., "Long-range weather forecasts through numerical and empirical methods," presented at Symposium on Long-range Prediction, Utrecht, The Netherlands, May 13, 1992

van den Dool, H. M., "Seasonal redistribution and conservation of atmospheric mass, and the role of water in the continuity equation," presented at NOAA/GFDL, Princeton, NJ, Sept. 24, 1992.

Wang, J., "Winter tropical-extratropical interaction during northern winter," presented at the CAC Seminar Series, NOAA Science Center, Camp Springs, MD, Dec. 5, 1991

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9.5 Grant/Contract Program

CAC continued support to universities and private industry to undertake diagnostic studies and research that contribute directly to the improvement of CAC's operational monitoring and prediction programs, as well as coordination of the Regional Climate Center Program. The results from each project are reported in the literature and in final reports to CAC. Each institution, title of study and principal investigator is listed below.

Start Date	Institution	Title	Principal Investigator
May 1992 (Renewal)	University of Maryland	Cooperative Institute for Climate Studies	Ellingson
Aug. 1992 (Renewal)	University of Chicago	Statistical Analysis of Stratospheric Temperature Data for Trend Analysis	Tiao
Aug. 1992 (Renewal)	UCAR	Scientific Program	Anthes

REGIONAL CLIMATE CENTERS PROGRAM

Start Date	Institution	Title	Principal Investigator
Mar. 1992	University of Nevada	Western RCC	Warburton
May 1992	University of Nebraska-Lincoln	High Plains RCC	Hubbard
May 1992	So. Carolina Water Resources Commis.	Southeastern RCC	Smith
June 1992	University of Illinois	Midwestern RCC	Kunkel
June 1992	Cornell Univ.	Northeastern RCC	Knapp
Aug. 1992	Louisiana St. University	Southern RCC	Muller

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9.6 CAC - Sponsored Seminar Series

Speaker: Dr. Huug M. van den Dool
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Ming Cai
Department of Meteorology
University of Maryland
College Park, MD

Title: "Low-Frequency Waves and Traveling Storm Tracks"

Date: October 1, 1991

Speaker: Dr. Ake Johansson
Department of Meteorology
Stockholm University
Stockholm, Sweden

Title: "Transient Wave Structures in the Atmosphere and in Models"

Date: October 7, 1991

Speaker: Dr. Brian Reinhold
Department of Meteorology
Stockholm University
Stockholm, Sweden

Title: "The Role of the Transients in Weather Regimes and Transitions"

Date: October 8, 1991

Speaker: Dr. Ake Johansson
Department of Meteorology
Stockholm University
Stockholm, Sweden

Title: "Baroclinic Constraints on the Upscale Energy Transport"

Date: October 29, 1991

Speaker: P. L. Houtekamar and J. Barkmeijer
Royal Netherlands Meteorological Institute
de Bilt, Netherlands

Title: "Skills Forecast with a 3-Level Quasi-Geostrophic Model"

Date: November 5, 1991

Speaker: Dr. Allan H. Murphy
UCAR Visiting Scientist
NMC/Climate Analysis Center
Camp Springs, MD

Title: "On the Quality of CAC's Monthly and Seasonal Forecasts"

Date: November 7, 1991

Speaker: Ming Cai
Cooperative Institute for Climate Studies
University of Maryland
College Park, MD

Title: "Physical Interpretation of Barotropic Instability"

Date: November 19, 1991

Speaker: Donald H. Wilhite
International Drought Information Center
University of Nebraska
Lincoln, NE

Title: "International Drought Mitigation Efforts"

Date: December 3, 1991

Speaker: Dr. Julian Wang
RDS Corp.
Contract Scientist, NMC/Climate Analysis Center
Camp Springs, MD

Title: "Winter Tropical-Extratropical Interaction During Northern Winter"

Date: December 5, 1991

Speaker: Dr. Jianfu Pan
SMART, Inc.
Contract Scientist, NMC/Climate Analysis Center
Camp Springs, MD

Title: "Energy Cycle Over the Tropical North Atlantic Ocean"

Date: December 12, 1991

Speaker: Dr. Kingste Mo
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "Linkages Between Tropical and Extratropical Circulation Anomalies"

Date: January 16, 1992

Speaker: Dr. Mary Voice
Climate Analysis Section
National Climate Center
Melbourne, Australia

Title: "Two Years of Operation of the Australian Seasonal Outlook Service -- Problems, Performances and Prospects"

Date: January 21, 1992

Speaker: Prof. Bin Wang
Department of Meteorology
University of Hawaii
Honolulu, HI

Title: "On the Annual Cycle of the Pacific Cold Tongue"

Date: January 23, 1992

Speaker: Prof. Bin Wang
Department of Meteorology
University of Hawaii
Honolulu, HI

Title: "A Simple Tropical Atmospheric Model of Relevance to Short-Term Climate Variations"

Date: January 24, 1992

Speaker: Prof. Sumant Nigam
Department of Meteorology
University of Maryland
College Park, MD

Title: "Structure of Oceanic and Atmospheric Low-Frequency Variability Over the Tropical and Indian Ocean"

Date: January 30, 1992

Speaker: Dr. Muthuvel Chelliah
RDS Corp.
Contract Scientist, NMC/Climate Analysis Center
Camp Springs, MD

Title: "Equatorial Pacific Sea Surface Temperatures and ENSO"

Date: February 6, 1992

Speaker: Dr. Suhung Shen
Department of Meteorology
University of Maryland
College Park, MD

Title: "Interannual Variabilities of the East Asian Summer Monsoon and Tropical SSTs"

Date: February 18, 1992

Speaker: John Janowiak
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "Diurnal Variations in Tropical Convection"

Date: February 25, 1992

Speaker: Dr. A. P. M. Baede
Head, Dynamical Meteorological Section
Royal Netherlands Meteorological Institute
de Bilt, Netherlands

Title: "Climate Change Policy in the Netherlands"

Date: March 3, 1992

Speaker: Dr. Jeffrey L. Anderson
UCAR Visiting Scientist
NMC/Climate Analysis Center
Camp Springs, MD

Title: "The Climatology of Blocking in a Numerical Forecast Model"

Date: March 12, 1992

Speaker: Dr. Thomas Smith
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "Spatial Correlations for SST and Improved Error Statistics for SST Optimal Interpolation"

Date: March 24, 1992

Speaker: Dr. Wilbur Chen
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "Large-Scale Low-Frequency Anomalies of a Comprehensive General Circulation Model"

Date: April 9, 1992

Speaker: Dr. Randy Dole
NOAA/ERL
Climate Diagnostics and Monitoring Laboratory
Boulder, CO

Title: "Large-Scale Cyclogenesis"

Date: April 9, 1992

Speaker: Prof. William Gray
Department of Atmospheric Sciences
Colorado State University
Fort Collins, CO

Title: "Interseasonal Prediction of Atlantic Hurricane Activity and ENSO"

Date: April 16, 1992

Speaker: Dr. Alan Robock
Department of Meteorology
University of Maryland
College Park, MD

Title: "Soil Moisture Calculations and Observations"

Date: April 28, 1992

Speaker: Dr. Jin Huang
RDS Corp.
Contract Scientist, NMC/Climate Analysis Center
Camp Springs, MD

Title: "Monthly Precipitation-Temperature Relations and Temperature Prediction Over the United States"

Date: May 21, 1992

Speaker: Dr. Edward S. Epstein
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "Prediction, Specification, and the Kalman Filter"

Date: May 26, 1992

Speaker: Dr. Klaus Wolter
CIRES
University of Colorado
Boulder, CO

Title: "Monitoring ENSO Using COADS with a Seasonally-Adjusted Principal Component Index"

Date: May 29, 1992

Speaker: Allen Basist
NOAA/National Weather Service
NMC/Climate Analysis Center
Camp Springs, MD

Title: "A Comparison Between Satellite Microwave and GDAS Tropospheric Temperatures (1979-1990)"

Date: June 18, 1992

Speaker: Morris McCutchan and Richard Chase
Pacific Southwest Research Station
USDA/Forest Service
Riverside, CA

Title: "Making Optimal Management Decisions Using Weather Forecasts"

Date: June 30, 1992

Speaker: James G. LaDue
NOAA/NESDIS
ORA/Satellite Applications Laboratory
Camp Springs, MD

Title: "Slide Show: Oklahoma Tornadoes"

Date: August 26, 1992

Speaker: Dr. Allan H. Murphy
Dept. of Atmos. Sci.
Oregon St. University
Corvallis, OR

Dr. Lev Gandin
NOAA/National Weather Service
NMC/Development Division
Camp Springs, MD

Title: "Economically Optimum Use of Meteorological Information, Part II: The Continuous Case"

Date: August 31, 1992.

Speaker: Dr. J. Sun
Dept. of Atmos. Sciences
Oregon State University
Corvallis, OR

Title: "Error Analysis on SSM/I Evaporation Estimates over the Global Oceans"

Date: September 1, 1992.

Speaker: Dr. Raimond Alfier
Free University of Berlin
Berlin, Germany

Title: "Stratospheric Temperature Changes after the Pinatubo Eruption "

Date: September 8, 1992.

Speaker: Dr. Michael Fiorino
Laboratory For Atmospheres
NASA/Goddard Space Flight Center
Greenbelt, MD

Title: "Computer-Induced Variability in the Climate of Atmospheric General Circulation Model"

Date: September 24, 1992.

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9.7 Visitors

Name	Affiliation	Date
M. Cai	Cooperative Institute for Climate Studies University of Maryland College Park, MD	Oct. 1, 1991 Nov. 19, 1991
H. Tuomenvirta	World Climate and Data Monitoring Programme WMO Geneva, Switzerland	Oct. 4, 1991
A. Johansson	Department of Meteorology Stockholm University Stockholm, Sweden	Oct. 7, 1991
B. Reinhold	Dept. of Meteorology Univ. of Stockholm Stockholm, Sweden	Oct. 8, 1991
V. Thapliyal	Director of Forecasting Indian Met Department New Delhi, India	Oct. 8, 1991
R. Heino	Finnish Meteor. Inst. Helsinki, Finland	Oct. 11, 1991
C.J. Schuurmans	Royal Netherlands Meteorological Inst. de Bilt, The Netherlands	Oct. 25, 1991
J. Barkmeyer P. Houtekamer	Royal Netherlands Meteorological Inst. de Bilt, The Netherlands	Nov. 5, 1991
I. Mokhov	Inst. of Atmos. Physics USSR Academy of Sciences Moscow, USSR	Nov. 6, 1991
G. P. Konnen	Royal Netherlands Meteorological Inst. de Bilt, The Netherlands	Nov. 8, 1991
D. Wilhite	Int'l Drought Infor. Center Univ. of Nebraska Lincoln, NE	Dec. 3, 1991
L. Rukhovets	SUNY Albany, NY	Dec. 23, 1991

A. Kano	Voice of America Washington, D.C.	Jan. 16, 1992
K. Gibbs	National Geographics Soc. Washington, D.C.	Jan. 17, 1992
M. Voice	Bureau of Meteorology Melbourne, Australia	Jan. 21, 1992
B. Wang	Dept. of Meteorology Univ. of Hawaii Honolulu, HI	Jan. 23-24, 1992
V. Miller	Weather Channel Atlanta, GA	Jan. 29, 1992
S. Nigam	Department of Meteorology University of Maryland College Park, MD	Jan. 30, 1992
D. A. Davenport	U.S. Fish and Wildlife Serv. Laurel, MD	Jan. 31, 1992
J. Segovia	National Institute of Meteorology Madrid, Spain	Jan. 31, 1992
T. Potter	Director, Western Region National Weather Service Salt Lake City, UT	Feb. 13, 1992
C. Brown	Institute of Water Research Michigan State University East Lansing, MI	Feb. 13, 1992
S. Shen	Department of Meteorology University of Maryland College Park, MD	Feb. 18, 1992
A. P. M. Baede	Head, Dynamical Met. Sec. Royal Netherlands Meteor. Institute de Bilt, The Netherlands	Mar. 3, 1992
J. Scialdone D. Irvine	National Space Science Data Center Greenbelt, MD	Mar. 5, 1992
S-D. Ko C. Evans	University of South Carolina Columbia, SC	Mar. 10-13, 1992

M. Lazovic	Head, Service of International Cooperation Federal Hydrometeor. Inst. Belgrade, Yugoslavia	Mar. 13, 1992
Dr. Z. Batjargal	Chairman, Minister of State Committee for Nature and Environmental Protection Ulaanbaatar, Mongolia	Mar. 24, 1992
J. A. Warburton	Western RCC Reno, NV	Mar. 24, 1992
K. E. Kunkel	Midwest RCC Champaign, IL	Mar. 31, 1992
R. Dole	Climate Monitoring and Diagnostics Lab., NOAA/ERL Boulder, CO	Apr. 9, 1992
I. Burton	Director, Canadian Climate Centre Atmos. Environmental Service Downsview, Ontario, Canada	Apr. 14, 1992
S. Lyons	Dept. of Meteorology Univ. of Hawaii Honolulu, HI	Apr. 15, 1992
W. Gray	Dept. of Atmos. Sciences Colorado St. University Ft. Collins, CO	Apr. 16, 1992
J. Derome	Dept. of Atmos. Sciences McGill University Toronto, Ontario, Canada	Apr. 24, 1992
A. Robock	Department of Meteorology University of Maryland College Park, MD	Apr. 28, 1992
P. J. Robinson	University of NC Raleigh, NC	Apr. 30, 1992 June 29, 1992
C. Rodgers	Dept. of Meteorology Penn State University State College, PA	May 6, 1992
J. Pelessier	Senior, MIC NWS/Forecast Office Raleigh-Durham, NC	May 12, 1992
N. Austin	Tennessee Valley Authority Knoxville, TN	May 28, 1992

K. Wolter	CIRES/U. of Colorado Boulder, CO	May 29, 1992
C. Landsea	Colorado State Univ. Ft. Collins, CO	June 29, 1992
N. Plummer	Australian Climate Center Melbourne, Australia	June 29, 1992
M. McCutchan R. Chase	Pacific SW Research Station USDA/Forest Service Riverside, CA	June 30, 1992
G.S. Golitsyn	Director, Institute of Atmospheric Physics Russian Academy of Sciences Moscow, Russia	Aug. 4, 1992
B. Rudoelfs	German Wetterdienst Frankfurt, Germany	Aug. 7, 1992
B. Mendbayaryn	Director, National Remote Sensing Centre State Committee for Environmental Protection Ulaanbaatar, Mongolia	Aug. 10, 1992
R. Allan	Div. of Atmospheric Research CSIRO Aspendale, Vic., Australia	Aug. 17, 1992
C. Koch	Climate Branch South African Weather Bureau Pretoria, South Africa	Aug. 17, 1992
A. H. Murphy	Dept. of Meteorology Oregon State University Corvallis, OR	Aug. 31, 1992
J. Sun	Dept. of Atmos. Sciences Oregon State University Corvallis, OR	Sep. 1, 1992
S. Q. Kidder	Chairman, Atmospheric Science Program University of Alabama Huntsville, AL	Sep. 3, 1992
R. Alfier	Free University of Berlin Berlin, Germany	Sep. 8, 1992
M. Fiorino	Laboratory For Atmospheres NASA/Goddard Space Flight Cntr. Greenbelt, MD	Sep. 24, 1992

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